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Adenoma of the Bronchus: A Clinical and Roentgenologic Study with a Report of Seven Cases[1]

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THE LARGE majority of primary bronchial neoplasms are malignant. The internist and the roentgenologist are encountering cases of bronchiogenic carcinoma with ever increasing frequency, and indeed it is now recognized that this tumor is among the commonest of malignant growths, occurring more often in autopsy series than any type except gastric cancer. It is also interesting to note that carcinoma of the bronchus has in the past twenty-five or thirty years increased in incidence to a considerably greater extent than can be accounted for by the advance of the average life expectancy.

More significant for the clinician than the increasing occurrence of bronchial tumors, however, is the fact that during the past twenty years rapid progress has been made in the development of more accurate diagnostic means of identifying the condition in its early stages. Moreover, the recent strides of the thoracic surgeons have made it possible in suitable cases to treat cancer of the bronchus by removal of an entire lung, and it has now been clearly and repeatedly demonstrated that at least a few of these lesions may be cured by prompt radical surgery if the diagnosis is established sufficiently early. Thus, with improvement of both diagnosis and the methods of attack, bronchiogenic neoplasms are no longer of solely pathological interest but also constitute a challenge to the ingenuity of the clinician.

Benign bronchial tumors, though much less common than the carcinomata, are by no means rare. Several types have been described, including adenoma, chondroma, fibroma, lipoma, and a few other unusual varieties. The so-called bronchial adenoma accounts for about 80 per cent of the group of benign growths and is therefore by far its most important member. This condition has been the subject of many controversies regarding its histologic origin, its potential malignancy and relationship to carcinoma of the bronchus, and its proper treatment. We shall maintain in this discussion that, regardless of pathologic terminology, the disease which has been generally known as "bronchial adenoma" fits into a fairly definite clinical pattern and that its prognosis is quite different from that of cancer. We believe, therefore, that it is of importance to attempt a distinction between these neoplasms and that only in the light of such a distinction can the risks of the various possible therapeutic measures be properly weighed at the present time.

[1] From the Departments of Medicine and of Radiology and Physical Therapy of the University of Minnesota. Read by title at the Twenty-ninth Annual Meeting of the Radiological Society of North America, Chicago, Ill., Dec. 1–2, 1943.

HISTORICAL

Prior to 1932, adenoma of the bronchus was not clearly distinguished as an entity. Review of the earlier literature reveals a good many case reports of tumors which can be recognized as belonging in this group, which were described as carcinoma, adenomatous polyp, vascular adenoma, etc., or were thought to be inflammatory polypi with epithelial metaplasia. Mueller, in 1882, gave the first clear description of a bronchial adenoma discovered at autopsy. Occasional similar reports followed. Von Eicken (1907) is credited with the first bronchoscopic removal of what was almost certainly a benign adenoma. In 1917 Jackson, in America, carried out a similar procedure. After 1920, the increasing use of bronchoscopy led to the discovery and local removal of several more of these growths; in some instances they were thought to be carcinomata and cures of cancer of the lung by bronchoscopic removal were claimed when further symptoms failed to develop.

In 1928, Reisner reported a case of bronchial adenoma with autopsy and discussed the pathology of the condition in detail, concluding that this neoplasm was benign but that it had characteristics suggestive of potential malignancy. He felt that adenoma could give rise to cancer. Reisner's paper prepared the way for the work of Wessler and Rabin, which appeared in 1932. These authors analyzed a series of 12 proved cases of adenoma of the bronchus and described the essential clinical features of the disease. Since that time at least 200 cases have been recorded in the literature. In general, however, very little has been added to the original clinical description of Wessler and Rabin. The more recent communications have dealt chiefly with the management of these tumors, have discussed their histologic origin, and attempted to determine the frequency of malignant changes.

INCIDENCE

About 6 per cent of primary bronchial new growths are adenomata. This figure appears small at first glance, but it assumes greater importance when one remembers that a large proportion of the bronchiogenic cancers are beyond the operable or curable stage when first seen. The adenoma, on the other hand, is usually anatomically operable if the patient's general condition will permit surgery. Churchill has stated that about a fourth of all resectable tumors of the bronchus belong in this group, so that among the curable bronchial neoplasms, adenoma is relatively common.

The incidence of adenoma of the bronchus by age and sex is in remarkable contrast to the corresponding statistics for carcinoma. Almost 80 per cent of adenoma patients exhibit symptoms referable to the disease before the age of forty, many in their twenties. In the case of cancer, 90 per cent of the victims are over forty. It is also uniformly true in all published series that about 60 per cent of bronchial adenomata occur in women, whereas carcinoma is notorious for its predominance in males, 90 per cent according to most reports. These striking differences in the age and sex groups most affected by the two tumors suggest strongly that they are fundamentally different, rather than two grades or stages of the same neoplasm.

HISTOGENESIS

Several opinions have been voiced regarding the histologic origin of bronchial adenoma and also concerning the type of neoplasm with which it should be grouped. Some of the earlier investigators, finding the lesion postmortem in association with bronchiectasis, felt that it might be an inflammatory polyp produced by the irritation of stagnant purulent bronchial secretions. They explained the presence of epithelial cells as being due to the process of metaplasia. It is now recognized that the adenoma is a true tumor and that the associated bronchiectasis, rather than being the cause of the growth, results from the long-standing obstruction of a bronchus.

As regards their cellular origin, some workers have considered these neoplasms to be closely related to the carcinoids (Mallory). Others have placed them in the groups of mixed tumors (Graham and Womack). The most generally held view is that they arise from the duct epithelium of the bronchial mucous glands. The latter theory derives support from the fact that adenoma of the bronchus is found only in the larger bronchi (10 mm. or more in diameter, as a rule), where the mucous ducts also occur. This hypothesis also helps to explain the frequent finding of extrabronchial extension of the tumor (outside the cartilaginous rings), since the mucous ducts also penetrate this layer.

PATHOLOGY

Grossly, the adenoma is a smooth, round or oval, pinkish tumor. The intrabronchial growth is frequently polypoid and may be pedunculated. In some instances, however, it is flat, sessile, and attached by a broad base. There is often extension through the bronchial wall with formation of an extrabronchial mass which may be larger than the intrabronchial portion. A recent article reviewed 19 cases, in 90 per cent of which part of the tumor was outside the bronchus.

Microscopically the adenoma is usually covered by bronchial epithelium, which frequently undergoes metaplasia to the squamous-cell type. Just under the epithelium is a layer of loose connective tissue which is often very vascular and is the origin of the profuse bleeding so commonly encountered in the disease. The tumor cells lie beneath the connective-tissue layer. They are rather small, cuboidal or polygonal, and grow in irregular masses and cords with occasional tendency to form glands. The cells have no apparent polarity or arrangement and look rather undifferentiated. They are very uniform in size and staining properties, however, and show few mitotic figures.

There is still a good deal of controversy as to whether these lesions are benign or of low-grade malignancy, and arguments are to be found in support of each contention. The bronchial adenoma grows slowly but shows definite invasiveness (through the bronchial wall), lack of orderly structure, and a strong tendency to recur after local removal. In other words, there is evidence of *local* malignancy. Distant metastasis, however, is rare in published cases. Less than five instances of well authenticated metastasis from adenoma have been recorded, and in only one or two of these cases was the patient's death attributable in any way to the direct effects of the tumor. It is possible that some of the typical bronchiogenic carcinomata originate as adenomata, but if so they give no symptoms until they become frankly malignant. Such an hypothesis, however, is not reconcilable with the known clinical course of proved bronchial adenoma, which characteristically gives well marked symptoms over a long period of time. The recent communication of Clerf and Bucher is most helpful, because these authors were able to follow 35 cases of adenoma for periods ranging from two to eleven years. Carcinoma developed in only one case while under observation. One of the patients remained free of any recurrence eleven years after local bronchoscopic removal of an adenoma. In other published reports based on the duration of typical symptoms, though not on direct observation, these growths are reliably estimated to have existed for twenty-five years or more without showing evidence of malignancy.

To summarize, we believe there is good pathological evidence of low-grade malignancy in bronchial adenoma and grant that it is a locally malignant neoplasm in the sense of invading beyond the wall of the bronchus. We maintain, however, that from the standpoint of prognosis a neoplasm which gives rise to lethal metastases in only 2 or 3 per cent of cases, and then only after a period of several years, must be distinguished if possible from cancer of the bronchus. The clinician, in planning the management of a bronchial tumor, must consider procedures involving

TABLE I: MECHANICAL EFFECTS OF BRONCHIAL TUMORS

Stage	Effect on Bronchus	Manifestation
Early	No obstruction	None
	Irritation of mucosa	Cough
	Erosion of mucosa	Hemoptysis
Moderately advanced	Partial obstruction	Dyspnea Wheeze — often localized. Impaired bronchial drainage resulting in fever, pneumonitis, purulent sputum, and eventually bronchiectasis
Far advanced	Obstruction, partial in inspiration, but total in expiration	Obstructive emphysema
	Total obstruction	Total atelectasis, usually with suppuration

considerable risk. His decision, in some instances, may depend upon the relative magnitude of the risk incurred by consenting to something less than radical surgical removal. Since the chance of death from malignant metastasis in bronchial adenoma is so slight, the tumor should, with this small reservation, be regarded as clinically benign when it is necessary to balance the risk of a therapeutic procedure against the mortality of the disease.

CLINICAL FEATURES

Although adenoma of the bronchus almost always remains benign as far as lethal metastasis is concerned, its effects upon the lung are extremely serious and in many instances ultimately cause death. The tumor grows slowly and gradually occludes the bronchus in which it arises. During this process repeated infections occur distal to the obstruction, and sooner or later the portion of lung involved is destroyed by recurring suppuration. Bronchiectasis is regularly produced, and more acute infectious processes such as suppurative pneumonia, pulmonary abscess, and empyema may occur and eventually prove fatal.

In the recognition of bronchial adenoma, the clinical history commonly provides valuable clues. Usually there have been episodes of pneumonia characterized by cough, purulent sputum, fever, and frequently pleural pain. These attacks of pulmonary infection are often severe and slow to resolve. They recur repeatedly in the same part of the lung. Between the bouts of acute inflammation, there are intervals of good health in most instances, during which, however, a cough may persist. (This occurrence of healthy intervals is in contrast to the usual clinical course of carcinoma, which progresses without remission.) Hemoptysis is a prominent symptom of adenoma, occurring at some time in two-thirds of the cases. Not infrequently bleeding is relatively profuse and may be repeated. The hemorrhage tends to start and stop abruptly and, even more than other types of hemoptysis, is apt in women to accompany the menses. As has been stated, cough is generally present once the neoplasm is well established, and this may or may not be productive, depending upon the degree of pneumonitis or bronchiectasis present. Wheezing, due to partial obstruction of the bronchus, is often a complaint, and the rhonchus may be localized by the patient or the examiner in one lung or even in a certain lobe. In advanced cases with marked bronchial obstruction dyspnea and cyanosis occur.

The physical signs of adenoma of the bronchus vary tremendously; they depend entirely upon the degree of bronchial occlusion and upon the type and extent of secondary changes which have been produced in the lung. The commonly encountered conditions are summarized in Table I. An early lesion may give no abnormal signs or may cause a coarse rhonchus distal to the tumor. Later, dullness,

râles, and diminished or tubular breath sounds may signify the presence of pneumonitis. In the late stages the signs are those of total atelectasis. A few cases at some stage show obstructive emphysema and in practically all there is some degree of bronchiectasis within a year or two after the onset of symptoms.

ROENTGENOLOGIC FEATURES

As might be expected from the nature of the process, the roentgen findings in adenoma of the bronchus are of the first importance in the recognition of the condition. While it is true that cases have been reported in which the tumor was so small that it did not interfere appreciably with the aeration of the lung and hence produced no x-ray findings whatever, such a situation must be exceedingly rare and was not encountered in our experience.

Roentgen examination presents two types of evidence with regard to benign bronchial tumors. The first, which was the only evidence available until recently, relates largely to the secondary effects of the obstruction. Thus atelectasis (Figs. 1a, 9), commonly accompanied by the "drowned lung" phenomenon (Fig. 3a), is a frequent finding; especially characteristic is its tendency to be intermittent and recurrent. The atelectasis may be band-like, producing linear areas of increased density with some general decrease in the radiability of the lung. More commonly it is lobar in type, with a whole lobe collapsed down into a paravertebral triangle of increased density, while the remainder of the lung on that side exhibits greater radiability than normal owing to the expansion of the uninvolved lobes. Secondly, the presence of pneumonitis (Figs. 5, 9), which is likewise remittent and recurrent, is suggestive. In this case, rather than the sharply demarcated dense shadow of an atelectatic lobe, there is an irregularly distributed non-homogeneous density in the area of involvement suggesting somewhat the appearance of an atypical pneumonia. Finally, the demonstration in simple roentgenograms (Figs. 4a, 5), or by means of bronchography (Figs. 1b, 4b), of bronchiectasis localized to one lobe should always suggest the possibility of a bronchial adenoma. The demonstration of a mediastinal mass (Fig. 8) resembling a tumor, with associated evidences of bronchial obstruction, should likewise lead to further investigation because of the possibility of an extrabronchial extension of such a tumor.

The addition of bronchography with iodized oil makes it possible to demonstrate with reasonable accuracy the presence of the associated bronchiectasis (Figs. 1b, 4b) and the location of the obstruction (Fig. 1b). The delineation of the typical "cap-shaped" defect in the bronchus (Fig. 1b) is frequently possible and lends added weight to the diagnosis. This type of defect is due to the layering of the iodized oil over the round, rather smooth tumor and is in sharp contrast to the more diffuse elongated "rat-tail" type of obstruction found in carcinoma of the bronchus.

Finally the use of body section roentgenography, during the past five years, has permitted the direct visualization of the tumor itself as a rounded, sharply defined, dense shadow seen in contrast to the air in the bronchus which surrounds it (Figs. 2a, 3b, 3c, 6, 8, 10). Unfortunately, it is not always possible to make this demonstration satisfactorily. When it is possible, however, it is of the first importance in the diagnosis of the condition. In some instances the tumor has been demonstrated more effectively in the body section roentgenograms than it has in the bronchograms made with iodized oil.

It goes without saying that the roentgen findings are partially inferential, partially suggestive, only rarely conclusive in the diagnosis of bronchial adenoma. The final diagnosis must be made with the aid of the bronchoscope and the microscopic examination of a biopsy specimen, but the detection of this lesion depends so much upon its consideration in any case of chronic lung disease that the suggestive findings obtained on roentgen examination

TABLE II: DIFFERENTIAL DIAGNOSIS OF BRONCHIAL NEOPLASMS

	Adenoma	Carcinoma
Age	80 per cent under 40	90 per cent over 40
Sex	70 per cent females	85 per cent males
Bronchoscopic appearance	Smooth, pink, oval or lobulated; often pedunculated. Bronchus not fixed. Troublesome bleeding on biopsy	Irregular, yellowish or gray; often ulcerated. Bronchus infiltrated and fixed. Bleed readily but not profusely
Clinical findings	Attacks of suppuration; intermittent with long healthy intervals	Suppuration or atelectasis, usually progressive. Steady downhill course
Bronchiectasis	Frequent, due to chronicity of course	Infrequent; course usually too rapidly progressive
Type of hemoptysis	Often profuse, with sudden onset and abrupt cessation	Usually only streaking, which is often continuous

are of the first importance in leading to further study. When there is added to the secondary findings described above the demonstration of a typical "cap-shaped" defect in the bronchograms or the positive shadow of a round, sharply defined mass within the lumen of the bronchus in the planigrams, the roentgen diagnosis of bronchial adenoma is highly reliable. In such instances, if bronchoscopy is unsuccessful or impossible, the roentgen evidence is the most conclusive obtainable.

In the follow-up study of such patients to determine the effects of conservative therapy or to decide on more radical measures, repeated x-ray examinations, particularly with planigraphy, have been of inestimable value to us. In this manner we have been enabled to follow the size both of the intra- and extrabronchial mass (Figs. 2, 8), to determine the effects of hemorrhage after bronchoscopic procedures (Figs. 2b, 8b), and to establish conclusively the improvement in the secondary lung changes which follows relief of the obstruction (Figs. 2d and 4a).

The roentgenographic findings and their value are well illustrated in the accompanying case reports.

BRONCHOSCOPY

The final diagnosis of adenoma of the bronchus is ordinarily made by the bronchoscopist. When the mass is visualized, its gross features (previously described) and absence of the infiltration and fixation of the bronchial wall so common in carcinoma are extremely important in arriving at a correct conclusion regarding the nature of the tumor. Biopsy or other instrumentation generally causes free bleeding. This may be profuse, and very often a portion or all of the bronchial tree on the involved side may be occluded by blood clot. In our experience this clot is best left to liquefy and be removed by natural processes; ordinarily it clears out within a few days. Attempts at bronchoscopic removal of the clot are often followed by further hemorrhage.

Pathologic identification of these neoplasms by microscopic examination of a small biopsy section may be difficult or impossible. In some instances no tumor cells, but only overlying epithelium and stroma are obtained. In others, the lack of differentiation of the cells leads to an erroneous diagnosis of carcinoma. It has therefore come to be our opinion that a diagnosis of adenoma of the bronchus must rest upon the total clinical picture including history, roentgen studies, and gross bronchoscopic findings. If all these features are in accord and indicate adenoma, a conflicting biopsy report should not be accepted as proof of cancer.

DIFFERENTIAL DIAGNOSIS

In most instances of bronchial adenoma, the diagnosis can be rather easily made with the methods now available, once the possibility of this condition is considered. The tumor occurs only in the larger bronchi and can usually be seen through the

bronchoscope. By the use of this method, supplemented by roentgenograms made with the technic mentioned above, the lesion can almost always be identified. The clinical features which we consider important, in addition to the roentgen findings, in distinguishing adenoma from carcinoma of the bronchus have been discussed and are summarized in Table II.

Bronchial adenoma may be confused, also, with chronic pulmonary tuberculosis, simple bronchiectasis, and inflammatory granuloma of the bronchus. The basis of such confusion is clear. All these conditions are characterized by chronic pulmonary infection with productive cough and varying degrees of fever. All of them regularly cause hemoptysis. Diagnostic errors will usually be avoided, however, if the clinician has bronchial adenoma in mind as a possibility. The patient with a chronic productive cough, recurrent hemoptysis, and a fibrocavernous destruction of one upper lobe, whose sputum is invariably negative for tubercle bacilli by all methods, must not be assumed to have pulmonary tuberculosis, but should be investigated by planigram, bronchogram, and bronchoscopy. The same applies to any case showing recurrent atelectasis or pneumonia in one portion of the lung, whether or not bronchiectasis is present in the involved area. The differentiation of inflammatory granuloma from adenoma of the bronchus may be possible only by microscopic examination of an adequate biopsy section for the presence of tumor cells. In general it may be stated that adequate diagnostic tools are at hand for the differentiation of these conditions provided the physician has in mind the possibilities.

TREATMENT

Adenoma of the bronchus has been treated by three general methods:

(1) *Bronchoscopic removal* by mechanical or electrosurgical means is helpful in many circumstances and remains the method of choice in certain cases. We believe that a young patient with an early adenoma, whose lung shows little evidence of damage and who can be closely followed, should have a trial of local removal, since in a considerable number of cases these tumors have not recurred during periods of observation up to twelve years. Particularly do we favor this course when the lesion involves the main bronchus so that pneumonectomy would be required for radical removal. In the patients who refuse pulmonary resection, and in a few whose tumor is so located as to forbid it (*e.g.*, Case 4), local removal and follow-up by planigraphy and bronchoscopy at intervals constitute the method of second choice. Marked symptomatic improvement will result in many instances. Also, all patients who are to undergo lobectomy or pneumonectomy should have preliminary local removal of the adenoma to permit optimum preoperative drainage of suppurative areas in the lung so as to minimize the surgical risk.

(2) *Irradiation:* X-ray therapy and the application of radon have been given but a limited trial. Most authors have had only a small experience with the method and feel that it is of slight value. Foster-Carter has found irradiation efficacious but reports two or three deaths from hemorrhage after treatment by this method, apparently because deep necrosis in the bronchial wall has eroded large vessels. The method probably deserves further investigation with carefully controlled dosage, for those who have used it most find bronchial adenomata to be somewhat radiosensitive.

(3) *Pulmonary Resection:* Most authors now feel that the majority of cases of adenoma of the bronchus, because of the high incidence of local recurrence and extrabronchial extension, will sooner or later require pulmonary resection. A recent article stated that this was the method of choice in 90 per cent of instances. This figure is perhaps too high, but it conveys the present trend of opinion among those interested in this subject. Clearly, total removal will give the most desirable end-result in treatment of a neoplasm which

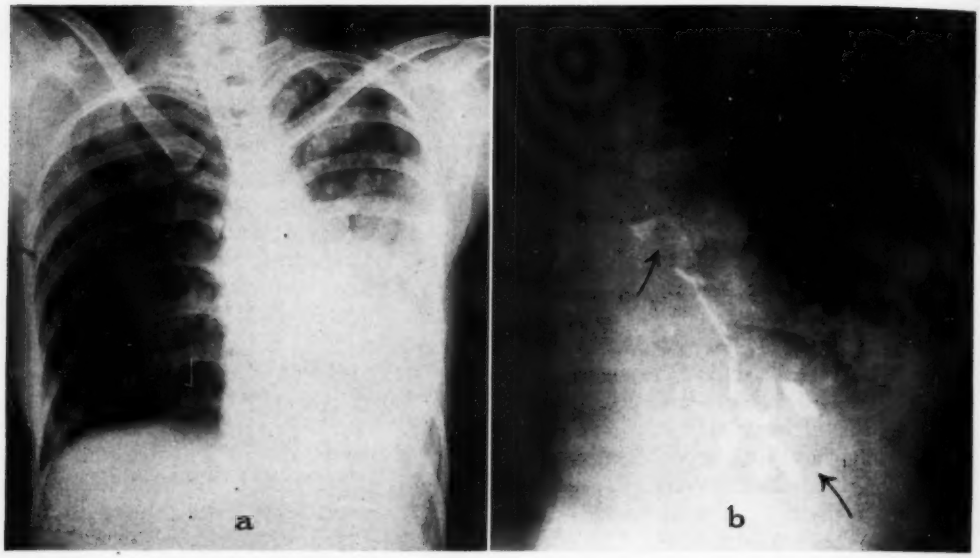

Fig. 1. Case 1. Bronchial adenoma, left lower lobe.
a. Postero-anterior roentgenogram exhibiting atelectasis of left lower lobe. Note mottled density, displaced heart, elevated diaphragm.
b. Bronchogram exhibiting typical "cap" deformity of bronchial adenoma (upper arrow) and bronchiectasis (lower arrow).

may recur, may produce serious pulmonary damage, and has occasionally been known to give rise to a malignant growth. There is no argument about this fact; the only disturbing feature is the risk assumed in the curative procedure. In some instances, the choice of a plan of management is simple and obvious, but in others this may be a difficult question to decide. We believe that after a thorough diagnostic study has been made, eac caseh must be carefully and individually assessed with respect to the amount of pulmonary damage, location of the tumor, and size of extrabronchial extension if one is present. On the basis of these features it should be possible to form a rough idea of the patient's prognosis if the neoplasm is *not* radically removed. Against this prognosis must be weighed the risk of whatever operative procedure is thought necessary to accomplish extirpation of the lesion. If the choice of radical surgery is in doubt, the patient and his family must be consulted, since either alternative may be somewhat hazardous, and the patient himself should have a voice in the decision.

The general policy which we follow at present in attempting to balance the risks in these cases is as follows. If the adenoma is so located that it can be removed by a lobectomy or by combined resection of the middle and lower lobes, we advise that this be done, except for the few patients selected for local removal, as previously described. The surgical risk of lobectomy is now so low (well under 5 per cent in most clinics) that this procedure gives the patient his best chance regardless of the type, location, etc., of the tumor. If pneumonectomy is required, the problem is complicated by the considerably higher mortality of the operation (hardly under 15 to 20 per cent for this type of case except perhaps in the hands of a very few men). In these cases, in general, we prefer to carry out local removal *via* the bronchoscope and observe the patient for a year or two. If the tumor recurs rapidly or if troublesome symptoms persist due to pulmonary suppuration, pneumonectomy is recommended as

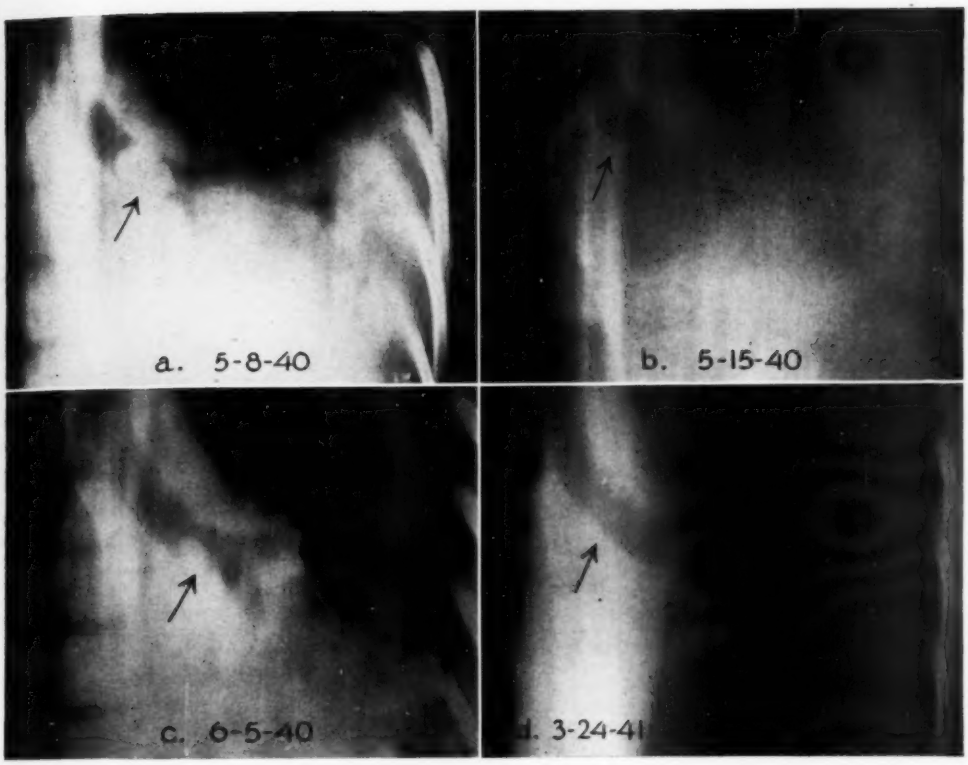

Fig. 2. Case 1. Body section roentgenograms.

a. First planigraphic study exhibiting sharply defined, rounded tumor (arrow) in left main bronchus. Note air column extending into upper lobe bronchus partly obstructed and complete obstruction of lower lobe.

b. Body section roentgenogram after first bronchoscopy with resultant hemorrhage. Note complete obstruction of air column (arrow) in left main bronchus, due to accumulation of blood, and increased density of entire left lung.

c. Re-examination after hemorrhage had cleared up, showing reduced size of tumor (arrow) and increased aeration of lung.

d. Final body section roentgenogram after adenoma had been removed by local excision. Note clear airway in left main bronchus (arrow) without any sign of tumor and almost fully aerated lung field.

less dangerous than permitting the patient to go without radical resection. If, on the other hand, the symptoms disappear with removal of obstruction to the bronchus, and the adenoma does not recur, the patient is simply watched by means of body-section roentgenograms and bronchoscopic examinations at regular intervals. The presence of a large extrabronchial extension of the growth, especially if it shows evidence of increasing in size, may influence the decision in favor of resection.

CASE REPORTS

CASE 1: A female, 29 years of age, was admitted May 20, 1940, with a history of pneumonia in the left lower lobe, fever, loss of weight, and a small hemoptysis. She had had a cough in February 1940 with fever and was sent to the Minnesota State Sanatorium, where she was given sulfonamide therapy and released seventeen days later, feeling well. Several weeks later the cough recurred. There was loss of appetite, and the patient was again admitted to the Sanatorium because tuberculosis was suspected. There an atelectasis of the left lower lobe was discovered and she was sent to the University Hospital for further study. One week prior to admission there had been a small hemoptysis. There was no history suggesting aspiration of a foreign body.

On examination the patient appeared acutely ill, with a fever of 101.6°, pulse 140, respirations 24. There was evidence of obstruction of the left main bronchus, with dullness, diminished expansion, and diminished breath sounds over the whole left lung.

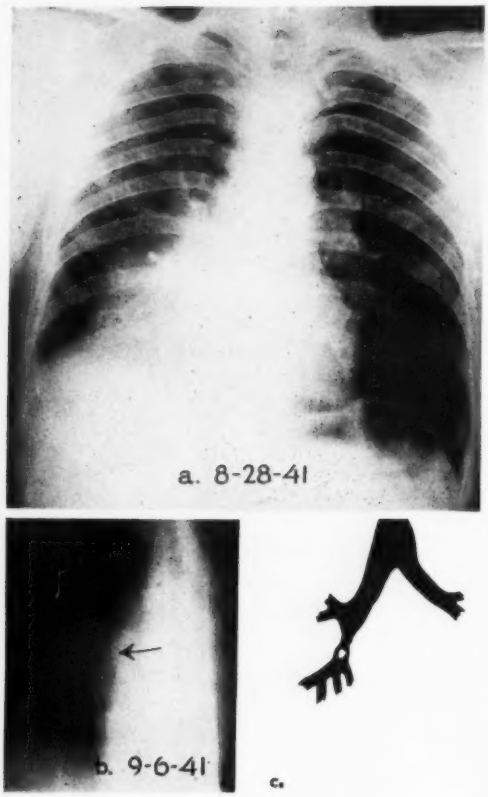

Fig. 3. Case 2. Bronchial adenoma, right lower lobe.
a. Postero-anterior roentgenogram showing typical "drowned lung" and atelectasis of right lower lobe and compensatory emphysema of right middle lobe.
b. Body section roentgenogram showing small, round, sharply defined tumor (arrow) within air column of right lower lobe bronchus.
c. Diagrammatic representation of bronchi and tumor as shown in b.

The mediastinum was displaced to the left. The significant laboratory finding was leukocytosis of 23,000 with 88 per cent polymorphonuclears. The diagnosis was obstruction of the left bronchus with atelectasis and infection of the distal lung.

Roentgen examination (Fig. 1a) revealed atelectasis and some "drowned lung" effect in the left lower lobe. The diaphragm was elevated and the heart was displaced to the left. The appearance was characteristic of bronchial obstruction. Bronchography (Fig. 1b) revealed a constriction of the left lower lobe bronchus with a fairly large cap-shaped filling defect, characteristic of adenoma. Distal to it a typical saccular bronchiectasis was shown.

Body section roentgenography was then undertaken (Fig. 2a). A sharply defined rounded shadow could be made out within the lumen of the left main bronchus just proximal to its bifurcation. This appeared to obstruct the lower lobe almost completely, the upper lobe only partially.

Bronchoscopy was done by Dr. Logan Leven, and the tumor was visualized as a smooth, round, pink mass in the left main bronchus. Following gentle instrumentation it bled freely and seemed to disappear from view, so that no tissue could be obtained. Following the procedure, the entire left bronchial tree became occluded by blood clot, and a "drowned lung" resulted (Fig. 2b). The patient became very ill, with temperature of 105°. Bronchoscopy was repeated for removal of the clot, but this only started fresh bleeding and the attempt was abandoned. As the clot absorbed, the patient improved gradually and the lung cleared. She left the hospital about five weeks after admission. At that time, the tumor was much smaller and the obstruction correspondingly relieved (Fig. 2c).

The patient gained weight rapidly after leaving the hospital and had very little cough. Only occasionally was there a small amount of purulent sputum. The only symptom was dyspnea on moderate exertion. She was followed in the Out-Patient Department until February 1941. The situation did not change appreciably. It was felt that the tumor should be removed if possible before it grew sufficiently to occlude the bronchus again. Accordingly, the patient was readmitted, and at this time the bronchial mass was removed through the bronchoscope by Dr. Leven. Only slight bleeding and no untoward reaction occurred.

Planigraphy was again undertaken (Fig. 2d). The clear airway in the left main bronchus is in sharp contrast to the examinations made on the previous occasions (Fig. 2).

In this patient there is undoubtedly much permanent lung damage in the form of bronchiectasis and fibrosis. At present râles are audible throughout her left lung. Further observation will be necessary to decide whether radical surgery will be required to manage this residual bronchiectasis. At present, however, she has no cough and very little sputum and has gone through two winters without difficulty. Therefore, the symptoms hardly justify a pneumonectomy at this time.

Comment: The brilliant delineation of this tumor and the recording of its gradual disappearance, as well as the filling up of the bronchus with blood, by the body section roentgenograms are notable. The apparently good results from local treatment are also to be observed.

CASE 2: A 32-year-old white male was admitted in August 1941. He had had pneumonia four times between the ages of ten and thirty-one. For one year a cough had been present, productive of one cupful daily of purulent sputum, which was sometimes blood-streaked and slightly fetid. The patient was well developed and well nourished. There was re-

duced expansion of the right hemithorax. On percussion, dullness was elicited over the lower half of the right lung posteriorly, with diminished breath sounds, a few coarse râles, and a transient expiratory wheeze in this area. Examination was otherwise normal. The laboratory findings were within normal limits. The sputum was foul, but bacteria were not found.

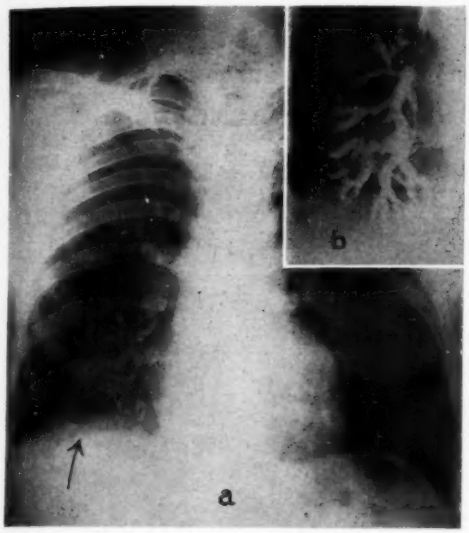

Fig. 4. Case 2. Bronchial adenoma of right lower lobe.
a. Postero-anterior roentgenogram after local removal of tumor, showing bronchiectasis (arrow).
b. Bronchogram of right lower lobe exhibiting dilatation of bronchi resulting from tumorous obstruction.

X-ray examination of the chest (Fig. 3a) showed consolidation in the right lower lobe with some evidence of atelectasis and drowned lung. The appearance suggested bronchial obstruction such as occurs from a tumor. Planigraphy was then done (Figs. 3b, 3c) and showed a rounded, sharply defined shadow in the right lower lobe bronchus characteristic of adenoma.

Bronchoscopy revealed a smooth, rounded, pink mass obstructing the right lower lobe bronchus, which bled easily and proved to be an adenoma. It was removed locally, but subsequent bronchography showed extensive bronchiectasis in the previously obstructed area.

The patient's symptoms disappeared in one month. He has been seen periodically since and his cough has not recurred. A check-up bronchoscopy in April 1942, eight months after removal of the growth, showed no recurrence, and a lipiodol study done over a year after the procedure showed the bronchus to be unobstructed. Ordinary roentgenograms of the lung (Fig. 4a) showed evidences of bronchiectasis, and persistent râles in the right lower

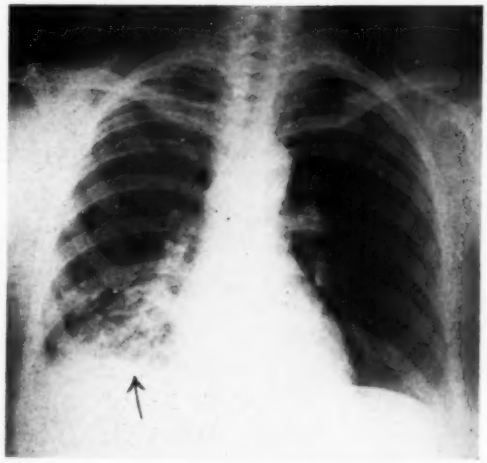

Fig. 5. Case 3. Bronchial adenoma, right lower lobe. Postero-anterior roentgenogram showing typical "honeycomb" lung of bronchiectasis. The presence of bronchiectasis confined to one lobe is suggestive of bronchial adenoma.

lobe testify to the presence of the bronchiectasis shown by bronchography (Fig. 4b). The patient's improvement was so striking that the surgical staff decided to defer the lobectomy, which had been planned to follow bronchoscopic extirpation of the adenoma.

Comment: In this case, also, the tumor was seen directly by planigraphy and the finding confirmed on bronchoscopy. The apparent good result following local removal through the bronchoscope is notable.

CASE 3: A female aged 26 presented herself on May 21, 1943, with a history of having had a cough since November 1942. She thought she had had an attack of pneumonia, with chills, fever, and pain over the right lung. She was in bed for twenty-six days, twelve of which were spent in a hospital. For some time after discharge from the hospital the temperature and pain continued. With the cough there was sputum, which was yellow. Later she coughed up dark blood. She was pregnant at the time. On April 10, 1943, she had another attack of what was thought to be pneumonia, having a chill, fever, perspiration, and prostration. She was taken to the hospital, where she apparently got better. Her baby was born May 10.

On entrance the patient was still coughing. The cough was productive and the sputum contained considerable amounts of blood. She thought she was a little hoarser than normal at that time. The physical findings showed some limitation of motion on the right. The breath sounds were diminished

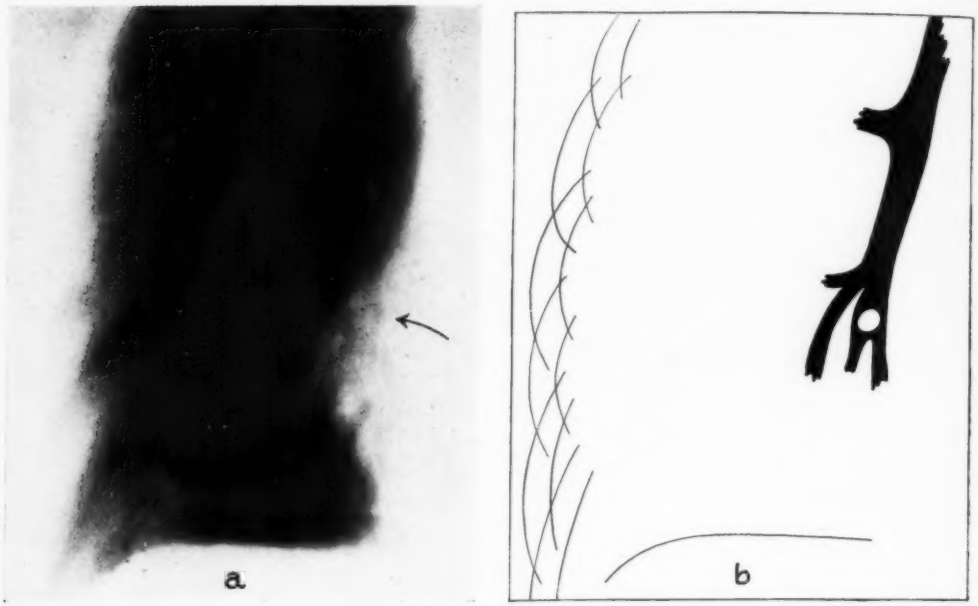

Fig. 6. Case 3. Bronchial adenoma, right lower lobe. a. Body section roentgenogram showing positive shadow of adenoma (arrow) in right lower lobe bronchus. b. Diagrammatic representation of bronchi and tumor as shown in a.

over the right lower lobe, and râles were heard here also. The first impression was an unresolved pneumonia.

The first roentgen examination of the chest (Fig. 5) showed an area of increased density in the right lower lobe with areas of rarefaction within it. The appearance suggested bronchiectasis with probably some type of pneumonitis. These findings were observed during routine fluoroscopy.

After physical examination by one of us (T. L.), the possibility of a bronchial adenoma was suggested. Body section roentgenography was carried out, and the bronchiectatic cavities were well seen. In the lumen of the right lower lobe bronchus a rounded, fairly well defined mass could be seen, which was quite suggestive of bronchial adenoma (Fig. 6).

Bronchoscopy was first done June 4. A smooth, globular, red mass was seen filling the lumen of the right main bronchus just at the point of division between the middle and lower lobes. Tissue was removed for biopsy and showed irregular cords and clusters of deep-staining cells, suggesting carcinoma but more likely bronchial adenoma.

Because of the questionable malignancy of the lesion, exploratory thoracotomy was advised. Surgery was undertaken on June 26, 1943, by Dr. O. H. Wangensteen, and the right middle and lower lobes were resected.

In the specimen a rounded tumor, slightly over 1 cm. in diameter, was found, just at the bifurcation of the right lower lobe bronchus, which seemed to occlude both the middle and lower lobes. The bronchi were markedly dilated distally, and there was a distinct bronchiectasis within the lung itself. The section of the tumor was exactly similar to that found on biopsy, adenoma of the bronchus being indicated. A section of a lymph node removed from the site of the lesion showed no evidence of disease. Convalescence was somewhat stormy, but the patient recovered with a moderate expansion of the remaining lobe. There is some residual fistula.

Comment: The typical history of repeated attacks of pneumonia together with persistent hemoptysis and physical evidence of bronchial obstruction led to the diagnosis in this instance. The roentgen examination revealing a localized bronchiectasis in one lobe is suggestive. Body section roentgenography gave positive evidence of the tumor, while the bronchoscopy and biopsy confirmed the diagnosis. The excellent results from lobectomy are notable, although insufficient time has elapsed to determine their permanency.

CASE 4: A 39-year-old female complained of cough, dyspnea, a sense of pressure over the right chest, and repeated hemoptysis of approximately

thirteen years' duration. When blood was first noticed in the sputum, x-ray examination had been made, and she was told there was "a spot on her lung." The hemoptysis seemed to have some relationship to her menstrual periods. There was no loss of weight.

The essential physical findings were some respiratory lag of the right chest and some diminution of breath sounds over the same area. The breath sounds were harsh, with an inspiratory thrill suggestive of bronchial obstruction.

The first roentgen examination was made on April 28, 1942, and revealed a mass in the right superior portion of the anterior mediastinum (Fig. 7). Body section roentgenography was carried out later (Fig. 8a) and demonstrated a mass protruding into the lumen of the right main bronchus and merging with the extrabronchial mass previously observed.

On May 15 bronchoscopic examination revealed the presence of an adenoma in the right main bronchus, the diagnosis being confirmed by histologic examination. Sheets and masses of cells in typical arrangement were noted. On June 20, endoscopic removal of the bronchial adenoma by coagulation and biting forceps was carried out. The procedure was well withstood. The convalescence was complicated by hydrothorax, and there was a marked increase of atelectasis following the procedure (Fig. 8b). Microscopic examination of the tissue removed on June 20 showed a small round-cell tumor, which was variously thought to be carcinoma and adenoma. Planigraphy on August 10, 1942, showed a marked decrease in the constriction of the bronchial lumen, but the extrabronchial mass was still present. A bronchoscopic biopsy was again obtained in November 1942, and there was a difference of opinion among the pathologists as to whether this was carcinoma or benign adenoma. A study of all the biopsies, however, led to a final diagnosis of benign adenoma. On examination in January 1943, the patient felt well and had no cough. Occasional small amounts of blood-streaked sputum were still being raised. On Jan. 14, 1943, bronchoscopic examination showed no increase in the size of the tumor of the right main bronchus. The base of the tumor previously removed with biting forceps was again biopsied and a small amount of tissue removed. Some decrease was present in the normal lumen due to the infiltration of the right lateral wall. On March 12, 1943, the patient felt well and was symptomless. There was no cough, dyspnea, or wheezing. Pneumonectomy was discussed, and it was decided not to undertake it because of the proximity of the tumor to the carina.

In August 1943 bronchoscopic examination showed an inflammatory area at the site of the adenoma. Very little impairment of the lumen of the main bronchus was noted and there was no pus or exudate. Biopsy revealed no evidence of tumor.

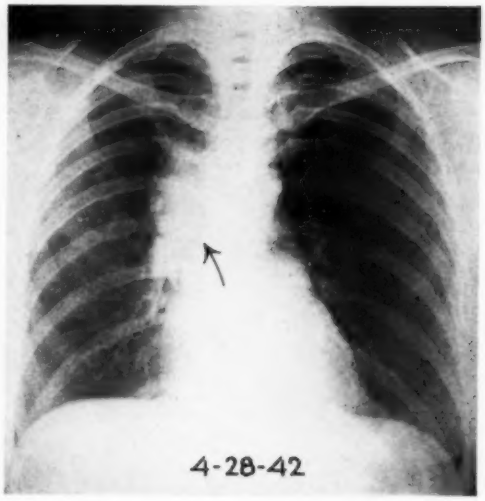

Fig. 7. Case 4. Bronchial adenoma with extrabronchial mass: postero-anterior roentgenogram exhibiting large mass in right superior mediastinum (arrow). Lateral views indicated that it was anterior in position.

Comment: In this case the presence of an extrabronchial extension of bronchial adenoma led to an erroneous roentgen diagnosis on the original examination. The correct diagnosis was suggested by reason of the typical history and physical findings and was confirmed by bronchoscopy. The planigrams, however, give an accurate picture of the progress of the lesion and the effects of therapy and indicate the exact location sufficiently to discourage attempts at radical surgery.

CASE 5: A male aged 38 was first seen at the University Hospital July 12, 1943. He had a history of cough and pain over the right lower chest for six or seven years, blood in the sputum for the past year, and a feeling of weakness. The cough and sputum had been present for about eight years. The patient dated the process to an appendectomy in 1935, following which a pleurisy developed. When he became excited during the past year, coughing began, he became weak, and sometimes coughed up blood in fairly copious amounts. He had no loss of weight and gave no history of a foreign body. He went to the Sunnyrest Sanatorium, where sputum examination and other studies showed no evidence of tuberculosis.

On physical examination at entrance here there were dullness to percussion over the lower right chest, decreased breath sounds, and increase of

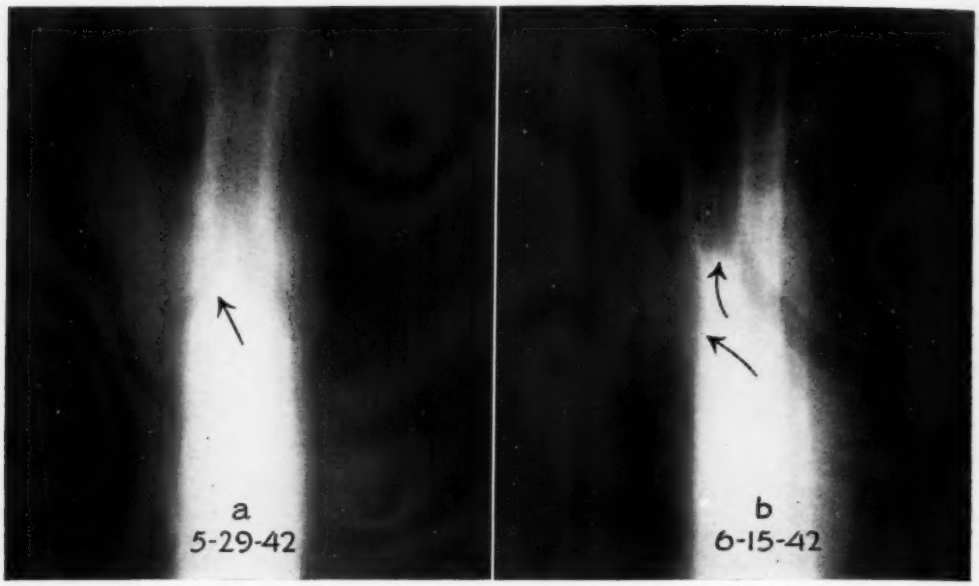

Fig. 8. Case 4. Body section roentgenograms.

a. Marked constriction of air column in right main bronchus (arrow) extending practically to carina. Note deviation of bronchus, angulation, and filling defect along lateral wall. The bronchus is both partially occluded by the intrabronchial tumor and displaced and compressed by the mediastinal mass.

b. Planigraphic study after bronchoscopy and hemorrhage. Note the complete occlusion of the air column at the carina by the accumulated blood (arrow) and the large extrabronchial mass (lower arrow). Later planigrams showed a considerable restoration of the airway of the right main bronchus after local removal of the tumor.

whispered voice sound over the lower half of the right chest posteriorly.

Roentgen examinations had been made by Doctor Paradis at the Sunnyrest Sanatorium and sent to one of us (L. G. R.) for interpretation. Bronchography was also carried out there. Further studies were made at the University Hospital, including planigraphy. On the postero-anterior roentgenogram (Fig. 9) there were observed marked density in the right lower lung field, retraction of the mediastinum and heart, and elevation of the diaphragm. The findings were characteristic, but with some "drowned lung" effect as well. On bronchography, a typical rounded, sharply defined cap-shaped defect was made out in the right main stem bronchus just at the level of the middle lobe orifice. Body section roentgenography revealed a round dense shadow within the lumen of the right lower bronchus at the same level (Fig. 10). All the findings were characteristic of a benign tumor.

Bronchoscopy was done on July 22, 1943, by Dr. Logan Leven and showed the right main bronchus to be normal to the level where the right middle lobe branch comes off. At this location there was seen a smooth, round, reddish mass practically filling the lumen, typical of bronchial adenoma. Biopsy was done. On microscopic examination there were found cords and groups of small dark-staining cells connected by fine bands of connective tissue, typical of adenoma of the bronchus.

Bronchoscopy was again done on July 28, and an effort at cauterization and removal was made, but bleeding occurred and it had to be discontinued. Bronchoscopy was repeated Aug. 6 and cauterization was again done, with some bleeding. This was repeated on Aug. 26. The mass was seen to be larger at this time, completely occluding the right lower lobe and almost completely occluding the middle lobe. Cauterization was again done. Because of the inability to remove the tumor completely, lobectomy was decided upon.

On Aug. 30, 1943, thoracotomy was undertaken by Dr. O. H. Wangensteen. A dense, adherent lung was found. There was pronounced atelectasis of the lower and middle lobes, which could not be inflated. Adhesions between the middle and upper lobes were found, so that the entire right lung had to be removed. It weighed 615 gm.

A large, typical rounded tumor projecting into and almost occluding the right lower lobe bronchus was seen in the specimen. This came within a centimeter of the bifurcation of the right main bronchus and appeared almost to ride over the orifice. Numerous small cavities were found in the lower lobe, filled with tenacious mucus. The bronchi elsewhere appeared normal. There was distinct dilata-

Fig. 9. Case 5. Bronchial adenoma, right lower lobe: postero-anterior roentgenogram showing partial atelectasis and some "drowning" of right lower lobe.

tion of the bronchi just distal to the tumor. Sections of the mass showed typical bronchial adenoma. The lymph nodes showed some sarcoidosis, but the relationship of this to the primary tumor is not clear. The patient had some drainage from the chest but made a fairly uneventful convalescence.

Comment: In this instance a tumorous obstruction of the bronchus with its effects of atelectasis, "drowned lung," and bronchiectasis was fully delineated by the various methods of x-ray examination. The exact location of the obstructing neoplasm and some evidence as to its benign character were clearly brought out. Obviously the bronchoscopic observations and the microscopic evidence of the nature of the tumor are the most certain diagnostic criteria, but the pathological process had been well exhibited by the roentgen examinations alone. Radical surgical procedure was adopted here because of the impossibility of complete local removal of the tumor. It was unfortunate that pneumonectomy became necessary, but recovery is taking place.

CASE 6: A 36-year-old American housewife was seen in the Out-Patient Clinic in August 1940. She presented a history of cough for two years, productive of thick, purulent sputum, varying in amount from an ounce to one-half cup in twenty-four hours. This had not been foul, but there had been hemoptysis of 2 ounces or so of bright red blood on four or five occasions during the two-year period. The

Fig. 10. Case 5. Bronchial adenoma, right lower lobe. a. Body section roentgenogram showing complete obstruction of right lower lobe bronchus and cap-shaped shadow of tumor protruding into the bronchus. b. Diagrammatic representation of findings shown in a.

patient had not lost weight and had had no fever as far as she knew. Examination of the chest showed slightly diminished expansion of the right side of the thorax. There were decreased breath and voice sounds over the lower third of the right lung posteriorly. No râles were heard and there was no impairment of resonance on percussion. The remainder of the examination was negative. Routine urine and blood examinations showed no abnormalities.

Roentgen examination revealed increased density in the medial portion of the lower right lung field. This was interpreted as probably indicating an area of atelectasis or "drowned lung" in the medial segment of the right lower lobe. A bronchogram showed obstruction of a branch of the right lower lobe bronchus with a rounded filling defect in the lipiodol shadow, fairly characteristic of bronchial adenoma.

At bronchoscopy, done by Drs. Robert Priest and L. R. Boies, a pedunculated, polyp-like mass was seen. This was smooth, movable, and covered by glistening mucous membrane. Biopsy revealed adenoma of the bronchus, and, at a subsequent bronchoscopy, the mass was removed *in toto*. It was attached by a long pedicle.

Three months later the patient had gained seven pounds and was coughing much less, but still raised one-half ounce or so of purulent sputum per day. A bronchogram in April 1941 showed filling of several saccular bronchiectatic pockets distal to the point of obstruction which were not reached by lipiodol injection before removal of the adenoma.

This patient went through a normal pregnancy and was delivered in July 1941. Since then her symptoms have continued to be mild, consisting of a slight cough with less than 5 c.c. of purulent sputum daily and no hemorrhages. Bronchoscopy in April 1942 showed recurrence of the adenoma in the right lower lobe bronchus. Lobectomy was refused and tissue was therefore again removed locally.

When last seen, in November 1942, the patient was in good health, had maintained her weight, and her symptoms were still in abeyance.

Comment: The typical history of hemoptysis was present here. The roentgen findings of bronchiectasis and atelectasis were characteristic. Body section roentgenography was not carried out, but bronchography showed a fairly typical cap-shaped defect. Recurrence of the tumor after local removal is not uncommon.

CASE 7: A boy aged 14 was admitted to the University Hospital Nov. 9, 1931, with a history of what appeared to be an attack of pneumonia in July 1931. Following recovery he coughed a great deal and raised some mucoid sputum. In August his temperature was found to be 102°. X-ray examination was made, and it was thought that he had pus in his chest. Thoracentesis was performed several times without results. The patient was pale and emaciated, the voice and breath sounds were greatly diminished over the right base posteriorly, and there was considerable dullness, also. Moderate leukocytosis was present.

The first x-ray examination, Nov. 9, 1931, revealed a density at the right base, the diaphragm being elevated and partially fixed. This was thought to be an encapsulated interlobar effusion. Exploratory operation was done and the pleura was fixed to the diaphragm. Later it was re-explored and some thick purulent exudate over the surface was found, but no free exudate.

After some efforts at drainage, on Jan. 26, bronchography was done. A partial pneumothorax was present on the right side and there was thickening of the pleura. Complete obstruction of the lower lobe bronchus was found, suggestive of a tumor or inflammatory constriction.

Bronchoscopy was then performed on Jan. 29, and edema of the mucous membrane in the right lower lobe bronchus was observed. A biopsy was done, and the first report was carcinoma. Later the pathologists thought this probably was chronic inflammatory tissue. Bronchography was again done, showing extensive bronchiectasis.

Following the bronchoscopy the patient improved a great deal, the coughing became less, and he began to increase in weight. Considerable dilatation of the bronchus was done through the bronchoscope, with marked improvement. The boy was again examined in 1933 and in 1934. On bronchography in 1934, the obstructed bronchus could be clearly made out. Re-examination of this bronchogram at a later date showed clear evidence of a cap-shaped deformity characteristic of adenoma.

The patient has been seen on repeated occasions since that time, and the biopsy specimens have been re-examined. The pathologists now believe that he has a typical bronchial adenoma. The patient is greatly improved and appears to be well, although there is a chronic atelectasis of the right lower lobe. He has refused further studies and further bronchoscopy, so that it is impossible to determine the exact status of the adenoma at this time.

Comment: This is a characteristic example of the errors which have occurred in the diagnosis of bronchial adenoma. The errors here were made by everyone concerned, including the pathologist, probably owing to lack of familiarity with the condition. Undoubtedly this is a bronchial adenoma which has continued a rather benign course without any particular interference.

SUMMARY

1. The clinical and roentgenologic features of adenoma of the bronchus are described, and its pathology and potential malignancy are briefly discussed.

2. A diagnosis of bronchial adenoma is usually rather easily established by roentgenologic and bronchoscopic examination, once the condition is suspected.

3. Evidence is presented in favor of regarding this tumor as a clinical entity separate from bronchiogenic cancer, even though the two cannot always be distinguished pathologically and in spite of the rare instances in which adenoma gives rise to cancer.

4. The chief reason for this division is a practical one: adenoma of the bronchus has a prognosis quite different from that of cancer and therefore permits the employment of a more conservative plan of therapy in properly selected cases when radical resection would be attended by a large risk.

5. Seven cases are presented to illustrate: (*a*) the typical clinical features of intrabronchial adenoma; (*b*) bronchial adenoma with an extrabronchial mass; (*c*) the various types of roentgen examination used in the diagnosis; (*d*) the value of body section roentgenography in the delineation of the tumor and in following the effects of treatment; (*e*) the results of various types of therapy in the several cases (namely, no treatment, local extirpation, and pulmonary resection).

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Iodinated Organic Compounds as Contrast Media for Radiographic Diagnoses

III. Experimental and Clinical Myelography with Ethyl Iodophenylundecylate (Pantopaque)[1]

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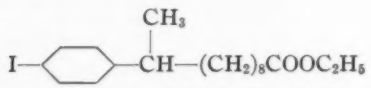
ETHYL iodophenylundecylate is one of a number of iodinated organic liquids that has been studied as a contrast medium for myelography. This new medium is a mixture of isomeric esters of which the principal constituent is probably that shown in the accompanying formula. It contains 30.5 per cent iodine and has a density of 1.263 at 20°C. The name Pantopaque[2] was coined for this mixture to provide radiologists and clinicians with a convenient designation. The chemistry of this and of related diagnostic aids is discussed elsewhere (1, 2).



Ethyl iodophenylundecylate (provisional).

Prior to its clinical use, ethyl iodophenylundecylate was tested intrathecally in dogs in a series of comparative experiments against iodized poppy-seed oil. In these tests the new medium proved to be much easier to handle, produced discomfort of shorter duration, and in most of the animals was almost completely absorbed within a year. The clinical results have paralleled those obtained in animal experimentation.

As is shown in Table I, iodized poppy-seed oil is twenty-two times as viscous as ethyl iodophenylundecylate at 25° C., and seventeen times as viscous at 37.5° C.

TABLE I: COEFFICIENTS OF VISCOSITY OF MYELOGRAPHIC MEDIA

Medium	$\eta^{25°C.}$	$\eta^{37.5°C.}$
Ethyl iodophenylundecylate	0.372	0.217
Iodized poppy-seed oil	8.06	3.76
Ratio	1:22	1:17

Because the new medium is so fluid, it is easily injected or removed with an 18- or 20-gauge needle and flows freely in the spinal canal immediately after injection. In dogs, however, where lumbar punctures

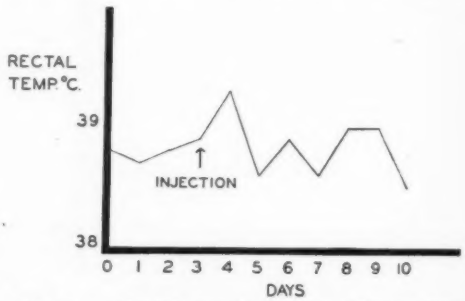


Chart 1. Typical transient fever following intrathecal injection of ethyl iodophenylundecylate in dogs.

are nearly impossible, and where the space relations of the canal are such that both media flow very slowly, practically none of the injected material can be removed.

Following intrathecal injection of 3 to 5 c.c. of ethyl iodophenylundecylate in dogs, there is a period of slight fever, lasting one or two days, as is shown in Chart I. During this time the dogs are clinically well, but a fair proportion may exhibit mild distress when the head is bent. After two or three days, however, this symptom dis-

[1] These studies were aided by a grant from the Research Laboratories of the Eastman Kodak Company. They were presented before the Radiological Society of North America, at its Twenty-eighth Annual Meeting, Chicago, Ill., Nov. 30–Dec. 4, 1942, and submitted for publication in June 1944.

[2] Pantopaque is a registered trade-mark.

appears. With iodized poppy-seed oil, on the other hand, there is no fever, but the period of distress when the head is bent may persist for ten to fourteen days. Sections taken from the spinal cords of dogs sacrificed at varying intervals show that both media are encysted after a lapse of about six weeks. The encystment is particularly noticeable in the cauda equina area and is not found generally throughout the cord. Typical sections showing the type of encystment that occurs are reproduced in Figure 1. As is evident from these photomicrographs, the size of the cysts with ethyl iodophenylundecylate is considerably less than that of those produced by iodized poppy-seed oil; this is probably referable to the greater viscosity of the poppy-seed oil. Cord sections taken at intervals from dogs injected intrathecally with ethyl iodophenylundecylate show that the physiological response about the cysts is essentially a foreign body reaction.

Acute toxicities for ethyl iodophenylundecylate were determined by intraperitoneal and intravenous injections. The LD 50 for intraperitoneal injections was found to be 4.6 gm./kilogram for mice and 19 gm./kilogram for rats. Control experiments with iodized poppy-seed oil showed no toxic effects with rats even when the medium was injected intraperitoneally at a level of 25 gm./kilogram. The injected ethyl iodophenylundecylate was completely absorbed in six weeks, however, while the iodized poppy-seed oil was not absorbed during the life of the experimental animal. The more rapid rate of absorption of the new medium may well be the sole cause of its relatively greater toxicity. Intravenous injections in dogs showed that ethyl iodophenylundecylate was without effect at a level of 0.5 gm./kilogram but was lethal at a level of 1.0 gm./kilogram. Emulsification with water containing small amounts of Igepon T (sodium olelylmethyltaurine) or of methyl cellulose reduced the toxicity considerably, and doses of 1.0 gm./kilogram were given intravenously to dogs with safety.

With the assurance from these experimental studies that the new medium was safe, it was first tested clinically on Nov. 23, 1940, by Drs. Paul Garvey and Nathaniel Jones in Case I, reported below. The absence of untoward developments led to its use in 4 additional patients. The satisfactory outcome in these first few cases was followed by a wider use, until now the new medium has been tested in numerous clinics. The most extensive series of cases[3] have been compiled by Dr. William P. Van Wagenen (Rochester, N. Y.), Dr. R. Glen Spurling (Louisville, Ky.), and Dr. William V. Cone (Montreal, Canada). From their experience it is evident that the best results are obtained if 3 to 5 c.c. of ethyl iodophenylundecylate are injected and

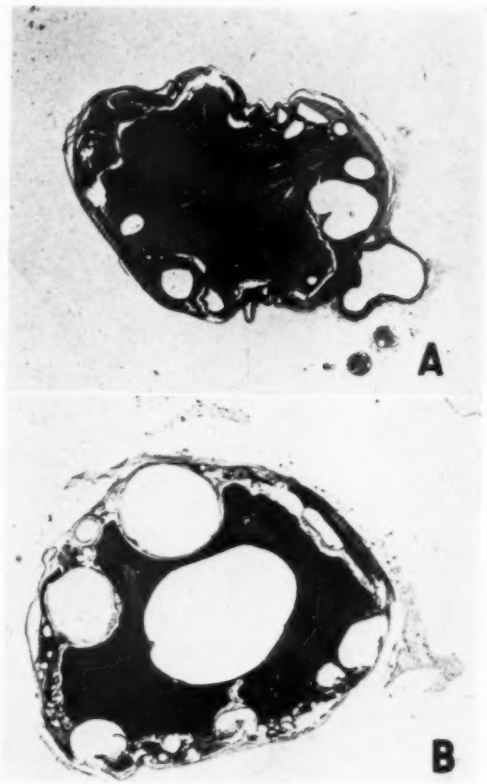


Fig. 1. Cyst formation in the spinal cord of dogs following intrathecal injection of (A) ethyl iodophenylundecylate and (B) of iodized poppy-seed oil. The sections represent extremes in pathology.

[3] As of November 1942.

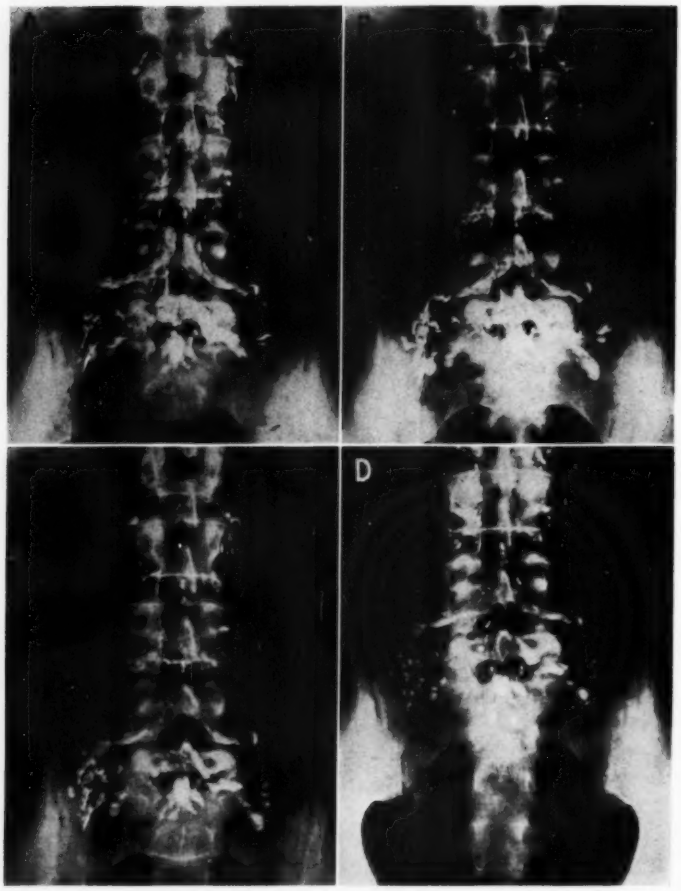


Fig. 2. Case II: Absorption of ethyl iodophenylundecylate in unusual case in which the nerve sheaths are filled with the medium. A. Immediately after injection. B. After three days. C. After forty days. D. After five months.

later removed by the general procedure of Kubik and Hampton (3). In this way up to 90 per cent of the injected medium is easily removed and the small amount of residuum is completely absorbed within a few weeks.

CASE HISTORIES

CASE I (Unit No. 171887): A 53-year-old male with complete paralysis from the waist down as the result of pressure on the dorsal cord from a dissecting aortic aneurysm was injected on Nov. 23, 1940, with 5 c.c. of ethyl iodophenylundecylate at L4 after removal of 8 c.c. of crystal-clear spinal fluid. Fluoroscopy showed a persistent constriction at L3 and L4, and also between L4 and L5. The patient experienced no reaction from the injection. Death occurred from a rupture of the aneurysm seventeen days later. A postmortem examination showed that the contrast medium was still mobile. Sections (Fig. 3) of the spinal cord showed a few polymorphonuclear cells around the nerve roots. There was no evidence of encystment in any portion of the cord.

CASE II (Unit No. 173025): A 28-year-old white male with embryoma of the left testicle with bone and pulmonary metastases was injected with 5 c.c. of ethyl iodophenylundecylate on Jan. 7, 1941. Films (Fig. 2) taken at intervals up to May 29, 1941, show a gradual absorption of over half of the injected contrast medium. Immediately after injection the Pantopaque became immobile as a result of filling the nerve sheaths, particularly the sheaths of the sciatic nerves. During the week immediately

Fig. 3. Case I: Section from the spinal cord seventeen days after injection of ethyl iodophenylundecylate. A few polymorphonuclear cells are seen.

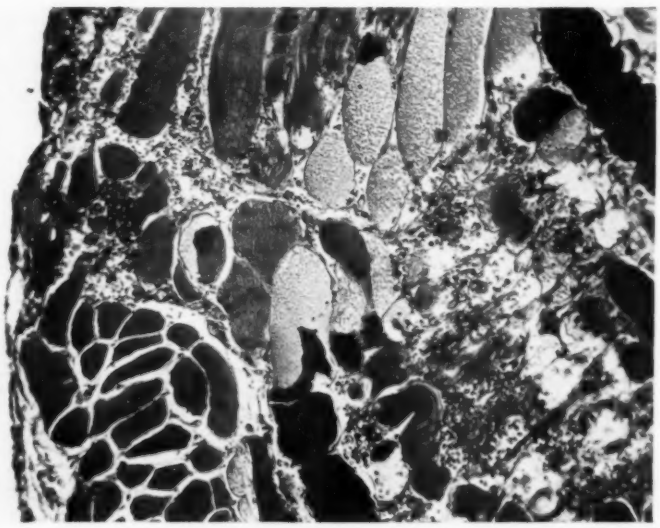


Fig. 4. Case III: Reaction about probable site of extradural injection of ethyl iodophenylundecylate.

following the injection, the patient had a slight paresthesia in the lower leg. Otherwise there were no clinical symptoms. Death occurred at home and an autopsy was not obtained.

CASE III (Unit No. 183121): A 29-year-old female with clinical symptoms of a ruptured nucleus pulposus was injected on Sept. 9, 1942, with 3 c.c. of ethyl iodophenylundecylate. A diagnosis of extramedullary compression between L4 and L5 was somewhat equivocal. The contrast medium was removed and the patient was placed on fracture boards. On Sept. 21, 1942, 3 c.c. of Pantopaque was again injected, but fluoroscopy showed that some of it was extradural. For several days the patient experienced increased leg pain, especially after manipulation. Finally, on Sept. 28, 1942, a third examination was made with 3 c.c. of ethyl iodophenylundecylate and a positive diagnosis of a

lesion at the disk space of L4 on the left side was obtained. A laminectomy was performed on Sept. 30. A section taken at the probable site of the extradural injection showed striated muscle and fibrous tissue. In the section reproduced in Figure 4 dense fibrous connective tissue is seen having a structure consistent with that of ligamentum flavum. In this tissue there is no evidence of any inflammatory reaction. Other portions of the section show striated muscle and areas of fairly loose connective tissue. Some of the striated muscle bundles appear to contain more than their normal number of nuclei, while others show considerable degenerative change. Instead of normal striated myofibrils the muscle sheaths contain a granular débris. This degeneration could be due to some local irritant, but similar changes are often seen without any known foreign matter in the vicinity. Several areas of the less dense connective tissue show infiltration by polymorphonuclear leukocytes in addition to many small round cells and a few larger monocytes. No definite droplets of contrast medium are seen, and there is no localized focal necrosis or abscess formation.

SUMMARY

Ethyl iodophenylundecylate (Pantopaque), a new contrast medium for myelography, is more fluid and is therefore more easily injected and removed than previously described oil-type contrast media. In addition to these physical advantages, the medium is absorbed from the subarachnoid space with relative rapidity.

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DISCUSSION

Capt. Frank H. Mayfield, M.C. (Percy Jones General Hospital, Battle Creek, Mich.): Doctor Strain and his co-workers have developed a material which, to my mind, is the most satisfactory for myelography that is yet available. That little is said in their paper of the clinical value of this material reflects the extreme conservatism of the men who have worked with Pantopaque, and this attitude is further evidenced by the rigid control which they have maintained over the product during its experimental stage.

I first became familiar with Pantopaque in January 1942. Prior to that time, Major Spurling and Major Bell of Louisville had used it a great deal and, on their recommendation, some was forwarded to me for experimental clinical use as a check on their results. I was not aware at the time of the work being done at other clinics except at the University of Rochester.

We had been using lipiodol for myelography and for the most part had found it a fairly satisfactory contrast medium. There were, however, two outstanding objections to its use. First, it is a very viscid oil with high surface tension and at times, on fluoroscopy, we saw filling defects which we thought were due either to herniated disk or tumor, which at operation proved to be small normal anatomical variations. Second, we found it difficult to remove lipiodol completely, because of its tendency to break up into droplets and its viscosity.

Our experience with pneumomyelography had never been satisfactory, though I am thoroughly aware of the excellent results obtained by Doctor Chamberlain in Philadelphia and Doctor Camp and his associates at the Mayo Clinic, and, indeed, by many other groups.

Pantopaque has solved many problems. It is a much less viscid oil than lipiodol, it moves within the spinal canal more rapidly, and because of its lessened surface tension it fills the root sleeves better and does not show false filling defects. Furthermore, it is easily removed. In most instances, one can recover by simple aspiration nearly all of the material, the usual experience being to leave one or two minute droplets.

The technic for removing the oil is that described by Hampton and Kubik. Lumbar puncture is done with the patient lying on his face, the needle being inserted at either the fourth or fifth interspace and carried through until it touches the anterior wall. The oil is then collected about the end of the needle under fluoroscopic observation, after which it is removed by simple aspiration.

Prior to entering the Army, I had used Pantopaque in approximately 30 cases. In most of them the oil was removed, but in 2 cases it was not removed. The cases in which the oil was removed showed no meningeal reaction. Those in which some of the oil was left showed a mild cellular response, and in one of the two in which none of the oil was removed, a mild meningismus occurred, lasting about three days. No residual symptoms were observed.

The highest cellular reaction was one thousand cells at the end of forty-eight hours. The usual count after administration of Pantopaque was 25 to 50 cells. This is almost identical with our experience with lipiodol. I think, therefore, that the toxic potentialities of the two drugs are the same.

Pantopaque, however, has two outstanding advantages. First, it is a more satisfactory medium for diagnostic purposes. Second, it can be removed more completely and more easily than lipiodol, thereby overcoming the one outstanding objection to the use of contrast media, namely, the medicolegal objection to leaving in the spinal canal a

foreign body which is visible on the x-ray plate.

Dr. Strain has mentioned the comparative absorbability of Pantopaque and lipiodol, and from my experience I find that Pantopaque is absorbed, or rather loses its radiopacity, much more rapidly than lipiodol. In those cases where only a few droplets of Pantopaque were left, it was no longer demonstrable after two to four months. In the two instances where about 3 to 4 c.c. of oil was left, it could not be shown on x-ray plates six months later. Lipiodol is visible usually for two to four years, and occasionally never disappears. While, as recommended by the author, Pantopaque should be removed, in the event that one is not successful in removing it, I am convinced that no harm will result.

There is one situation in which lipiodol is slightly more satisfactory than Pantopaque. Lesions of the cervical area are sometimes difficult to visualize with Pantopaque because the oil moves so rapidly that the defect is missed. With the more viscid lipiodol, small cervical deformities will be seen that might be missed with Pantopaque.

Iodinated Organic Compounds as Contrast Media for Radiographic Diagnoses

IV. Pantopaque Myelography[1]

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SINCE THE introduction of Pantopaque[2] in 1941 as a diagnostic aid in contrast myelography (1), 150 Pantopaque myelograms have been made at Strong Memorial and Rochester Municipal Hospitals. The fluidity of the new medium has greatly simplified myelography, and, through this property, the results obtained in the demonstration and study of minimal and maximal defects of the subarachnoid space have been especially satisfactory. Analysis of the results shows that the accuracy of Pantopaque myelography, based on cases that have come to operation, is 95 per cent. Errors both in the use of the medium and in the radiological interpretation appear to be due more to subjective factors than to Pantopaque itself; thus, in the series reported here, most of the errors occurred among the first 50 cases. Since a personnel of varied degrees of experience was involved, these errors probably represent the training period required to obtain high accuracy.

MYELOGRAPHY WITH PANTOPAQUE

Pantopaque is particularly satisfactory in contrast myelography of the lumbar and cervical regions of the spine. The series reported here, however, includes so few cervical myelograms that the discussion will be limited to the lumbar region.

To reduce the excretory load on the body to a minimum, Pantopaque should always be removed from the spinal canal after the examination has been completed. This is easily accomplished by the procedure of Kubik and Hampton (2) provided a satisfactory mid-line puncture is made for the injection of the medium. With a good mid-line puncture the examination, including injection and removal, usually may be completed within fifteen to twenty minutes.

Position of Patient: The patient is placed prone on a tilting fluoroscopy table with the head turned to either side. The hands grasp the edge of the table top at the level of the shoulders so that they will be out of the way, and so that the patient can steady himself during the examination. A small pillow is placed under the lower portion of the abdomen in order to straighten the lumbar curve moderately. The feet are placed firmly against the ftoorest of the tilt table.

Injection of Pantopaque: Sterile precautions should be employed as in a routine lumbar puncture. The injection is made in the mid-line, usually between the third and fourth lumbar spinous processes. If a lesion is suspected at that level, however, the interval above or below (preferably below) should be selected. If injection in the lumbar subarachnoid space is not feasible, cisternal injection may be employed. After the skin and the subcutaneous tissues have been anesthetized by infiltration with procaine, an 18- or 20-gauge needle, preferably with short bevel, is introduced into the subarachnoid space. After the ligamentum flavum has been encountered, the needle is inserted gradually, with great care. When the operator is certain that the needle has entered the subarachnoid space, the stilette is removed, and 3 to 5 c.c. of spinal fluid is aspirated and collected for protein determination. A previously prepared 5-c.c. syringe containing 3 c.c. of Pantopaque is then secured to the adaptor of the needle

[1] Accepted for publication in July 1944. Aided by a grant from the Research Laboratories of Eastman Kodak Co., Rochester, N. Y.

[2] Registered trade-mark.

and the contrast medium is slowly injected. This should be accomplished easily; if marked resistance is encountered, the exact position of the needle should be checked. When the Pantopaque has been introduced into the subarachnoid space, the syringe is detached from the needle and the stilette is replaced. A sterile gauze dressing is then placed over the needle and the patient is ready for the examination.

Fluoroscopy and Roentgenography: After the examiners have become dark-adapted, a fluoroscopic examination is made. The Pantopaque should be seen pooled in the middle lumbar region and near the point of the needle. Normal landmarks are then determined so that each interspace may be recognized on examination. A marker is applied to the back of the patient to label and to lateralize the films. Should the amount of injected Pantopaque prove to be too small, because of a large subarachnoid space, an additional 3 c.c. should be injected. The foot of the tilt table is first lowered gradually, and the flow of the column of Pantopaque is studied carefully. When the Pantopaque has collected in the terminal portion of the subarachnoid space, the table is then tilted slowly in the opposite direction, and the flow of the medium is again observed. To prevent the Pantopaque from passing into the cranial ventricles, where it may be immobilized, or from flowing too rapidly over the lumbar curve, which may lead to globulation, the examiners should avoid lowering the head of the patient too rapidly. These maneuvers may be repeated until a satisfactory examination has been completed. Sometimes it may be desirable to roll the patient from side to side in order to study each root adequately.

During fluoroscopy the movement of the image of the column of Pantopaque is observed closely for deviations in flow. If the image is indented, or if the flow of the column is partially or completely arrested, the behavior of the Pantopaque in the region of the vertebral column in which the defect occurs is carefully studied. Posteroanterior roentgenograms are taken routinely to demonstrate the third, fourth, and fifth lumbar intervertebral disk spaces. To demonstrate medially located lesions, the postero-anterior views may be supplemented with lateral and lateral-posterior roentgenograms. Defects demonstrated must be constant, and there must be agreement among the observers as to their presence before concluding the examination. Average technical factors that may be employed for the spot films are as follows: distance, 25 inches; kv. p., 85; ma., 100; time, 1/10 to 3/10 second, depending on the thickness of the patient. The area under investigation is diaphragmed as closely as possible to provide the maximum contrast possible. For the lateral and lateral-posterior views a Potter-Bucky diaphragm should be employed. It is essential that the fluoroscopic table be equipped with an efficient apparatus that permits rapid switching from fluoroscopy to roentgenography.

Removal of Pantopaque: At the completion of the examination, the Pantopaque is collected around the tip of the needle under fluoroscopic visualization and aspirated by means of an empty sterile syringe attached to the lumbar puncture needle. It is usually possible to remove 80 or 90 per cent of the injected Pantopaque without difficulty, but success in removing all the medium is determined usually by the accuracy with which the mid-line puncture was made. The amount removed can be identified in the barrel of the syringe, where it forms a layer under the spinal fluid simultaneously aspirated. Sometimes it is necessary during aspiration to turn the needle gently when its bevel becomes blocked by a nerve root or a meningeal margin. Occasionally the medium must be maneuvered under the tip of the needle two or three times under fluoroscopic visualization before all of it can be removed. In rare instances all these procedures are unsatisfactory, in which case the simplest practice is usually to make another lumbar puncture at a lower level, for example between L5 and S1. At all events, before removing the needle a roentgenogram should be taken

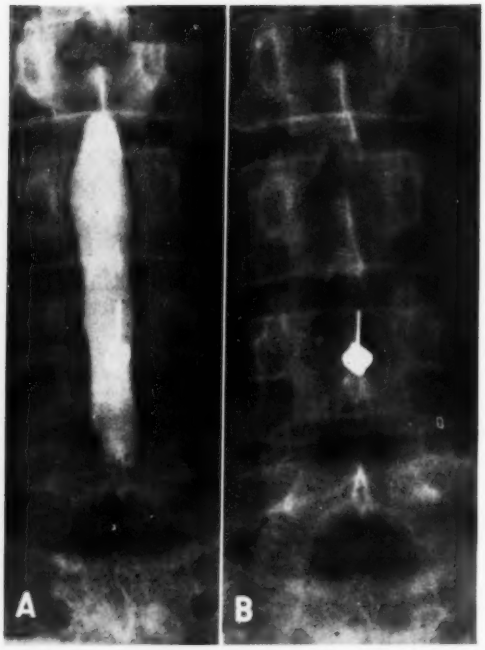

Fig. 1. A. Normal Pantopaque myelogram. B. Complete removal of medium. Time for complete examination with injection and removal, 15 minutes

after aspiration to check conclusively how much Pantopaque has been removed. After processing this final film, the needle is withdrawn and a sterile dressing is applied. A normal Pantopaque myelogram with complete removal of the medium is reproduced in Figure 1.

After-Care of the Patient: The patient may be permitted to move himself from the fluoroscopic table to his bed, but the same precautions are taken as after a routine lumbar puncture. The patient is kept flat on his back for six to twenty-four hours. If the examination has been carefully done, there should be little discomfort. When the contrast medium is not removed, an occasional patient may experience transient symptomatic abnormalities consisting of some muscular aching, headache, slight paresthesia in the lower extremities, and infrequently slight temperature elevation. Such symptoms may last twenty-four to thirty-six hours. No sequelae have been observed.

Contraindications: Pantopaque should not be injected where a lumbar puncture is contraindicated, nor within ten days of a previous lumbar puncture. The latter precaution is necessary to avoid subdural and extra-arachnoid extravasations.

ANALYSIS OF RESULTS

Of this series of 150 cases examined by Pantopaque myelography, 97 were surgically explored. In 5 cases the operative findings were at variance with the radiological interpretations, giving a diagnostic accuracy of 95 per cent in this group. Four of the errors occurred among the first 50 cases. In 2 of the cases erroneously diagnosed defects were found radiologically at L4, but in neither was a lesion discovered at operation. In both instances it is possible that the exploration may have been incomplete, since the defects were prominent on the myelograms. The other 3 cases were interpreted as normal on the basis of the radiological findings. Two of these patients proved to have herniated disks at L5, and the third to have syringomyelia. Review of the roentgenograms of the cases with disks at L5 showed that the interpretations were too cautious. The error in the third case may be attributed to faulty technic, since the fluoroscopic notes contained a reference to a delay of the movement of the Pantopaque column at C6.

In the 53 cases which were not explored, clinical and radiological evidence disagreed in only 2 instances. In each of these cases the clinical findings pointed to a herniated intervertebral disk, but in neither did the myelograms confirm this impression. Although herniated intervertebral disks were diagnosed both clinically and radiologically in about half of the remaining cases, operation was performed in none. Subsequent follow-up of this group, and of the group with negative diagnoses, should be valuable both clinically and diagnostically.

MINIMAL AND MAXIMAL DEFECTS

The reproductions in Figures 2 and 3 of two myelograms from the series of 150 serve to illustrate the value of the fluidity

of Pantopaque in contrast myelography. In the first case (Fig. 2) there is a minimal defect with an absent root. Defects of this type are easily shown with Pantopaque, although such a lesion is seen more clearly on the roentgenogram than during fluoroscopy. For this reason it is desirable to

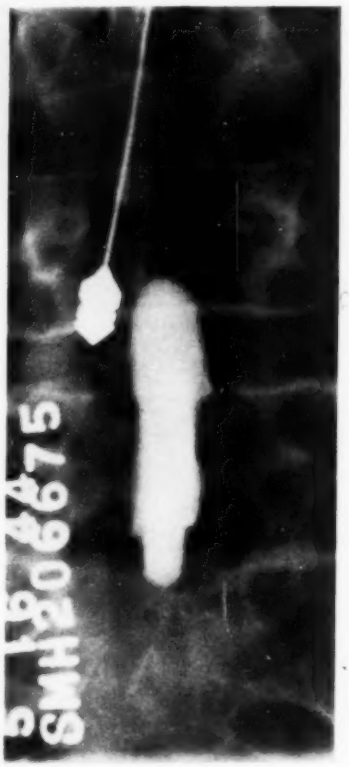

Fig. 2. Minimal defect with absent root at L4.

process the films during the course of the examination, so that it will not be necessary to repeat the injection and removal of the medium should the results be equivocal. In the second case (Fig. 3) a rather unusual multiple defect is shown in the myelogram. Here, too, the fluidity of Pantopaque is responsible for the result. These illustrations serve to emphasize that the extremes are usually the most difficult defects to demonstrate accurately. Defects intermediate in size are readily recognized both during

Fig. 3. Multiple defects at L3 and L4.

fluoroscopy and roentgenographically. Complete obstructions, particularly those at L5, are frequently difficult to differentiate from congenital variations of the sac in this area. In this connection, the studies of Horwitz (3) on the anatomical variations of the lower lumbar and sacral regions show that the termination of the caudal canal varies greatly from individual to individual. In those cases where a high termination of the lumbar sac is seen during fluoroscopy, a roentgenogram should be taken with the patient in a nearly erect position. The differentiation between a high termination and a block can be determined usually from the film. A high termination will show a tapering of the lumbar sac with the sacral root sleeves clearly evident, whereas a block will present an abrupt transverse cut-off of the Pantopaque column.

DISCUSSION

When Pantopaque was developed (1), an absorbable medium was the goal. Subsequent experience has shown that the fluid character of the new medium is an equally valuable property. Because of the fluidity of Pantopaque, myelography may be carried out rapidly and with great accuracy, as is shown in this series. Similar conclusions have been reached by Spurling and Thompson (4) and by Bradford (5)[3]. Detailed discussion of the types of defects seen on the myelograms is unnecessary, since they are essentially the same as those obtained by the more viscous iodized oils. These defects have been well described by Hampton and Robinson (6), Camp (7), Robinson (8), and Hyndman, Steindler, and Wolkin (9), and have been summarized by Bradford and Spurling (10).

Although the fluidity of Pantopaque is regarded usually as an asset, it has been cited by Pugh (11) as a disadvantage, in that the medium flows too easily and may globulate as it passes over the lumbar curve. In the series discussed in this paper, globulation has been uncommon and, where it has occurred, the globules could be reunited easily. The same experience has been reported by Hyndman, Steindler and Wolkin (9).

In spite of an extended experience with Pantopaque over a period of three years, the rate of absorption of the medium in man cannot be given with any exactness. If the conditions within the spinal canal are such that a marked degree of globulation of the residual Pantopaque occurs, or if the medium is spread over a large surface, the rate of absorption in man appears to approach the rate of 3 c.c. per year that was noted in dogs (1). On the other hand, when the medium is contained in the cauda equina region, the rate of absorption is so slow that it may be of the order of 0.5 to 1.0 c.c. per year. Provisionally, the rate of absorption may be set at 1 c.c. per year. Observations by several groups, particularly by Wyatt and Spurling (12), confirm this value.

[3] Editor's Note: See also SCOTT, W. G., AND FURLOW, L. T.: Myelography with Pantopaque and a New Technic for Its Removal, in this issue of RADIOLOGY, pp. 241–249.

SUMMARY

The results in 150 cases of Pantopaque myelography show that use of the new medium simplifies the procedure and leads to high accuracy. The technic of lumbar myelography is described in detail.

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Myelography with Pantopaque and a New Technic for Its Removal[1]

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and

COMMANDER LEONARD T. FURLOW, (MC) USNR

As the treatment of intraspinal protrusion of intervertebral disks becomes more common, increasing efforts are being made to find a simple and accurate but safe objective method for the diagnosis of this disorder. Without entering into a detailed discussion, it is safe to state that neither air, lipiodol, nor thorotrast has proved to be the ideal contrast medium. With air there is often insufficient contrast for clear definition of minor protrusions. With lipiodol the removal of the oil is often inadequate and at times uncomfortable for the patient. Removal of thorotrast is time-consuming and usually incomplete, so that its use is not without risk.

In an effort to find a more satisfactory medium, Warren, Strain, Plati, and associates (1, 2) developed ethyl iodophenylundecylate, a mixture of isomers obtained by the addition of iodobenzene to ethyl undecylate in the presence of aluminum chloride. It contains 30.5 per cent of iodine in firm organic combination. It is called "Pantopaque." The chemistry and the clinical uses of this product were described at the 1942 meeting of the Radiological Society of North America. These investigators state that Pantopaque is slowly absorbed from the spinal canal—3 c.c. being absorbed within a year. It is a clear, colorless oil, less viscid and lighter than lipiodol but heavier than spinal fluid. It is considered to be inert, and so far there have been no reports that it produces an irritation of the meninges. Because of these properties, Warren and his associates were able to aspirate it more easily from the spinal canal and recommended it as a medium for myelography. The product was manufactured by the Eastman Kodak Company, and its distribution was limited to the Armed Forces during the trial period. The second clinical report was made by Spurling and Thompson (3), who used Pantopaque in over 200 cases. Their results were so satisfactory that "Pantopaque myelograms are made routinely on all disk patients at the Walter Reed General Hospital, where surgery is contemplated." They, like the Warren group, removed the oil by aspiration with a syringe.

The purpose of this paper is (1) to relate our experiences with Pantopaque; (2) to describe a new and satisfactory method for the removal of the oil; (3) to comment briefly on the indications for spinal myelography.

Pantopaque in our experience has been a satisfactory contrast medium for spinal myelography. It is of about the same opacity and hangs together in one mass almost as well as lipiodol. The glass ampule in which it comes contains 3 c.c., a sufficient quantity. Its use has produced no reactions of which either we or the patients are aware. Its great advantage lies in the fact that it is much easier to remove from the spinal canal than lipiodol. All in all, we consider it superior to other contrast media and will continue to use it until something better is developed.

The radiographic examination is done in the usual way. Thirty minutes prior to the examination the patient is given a quarter of a grain of morphine sulfate hypodermically to allay his anxiety and to make him a little drowsy. This is not

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[1] The opinions or assertions contained herein are the private ones of the writers and are not to be construed as official or reflecting the views of the Navy Department or the naval service at large.

Read by title at the Twenty-ninth Annual Meeting of the Radiological Society of North America, Chicago, Ill., Dec. 1–2, 1943.

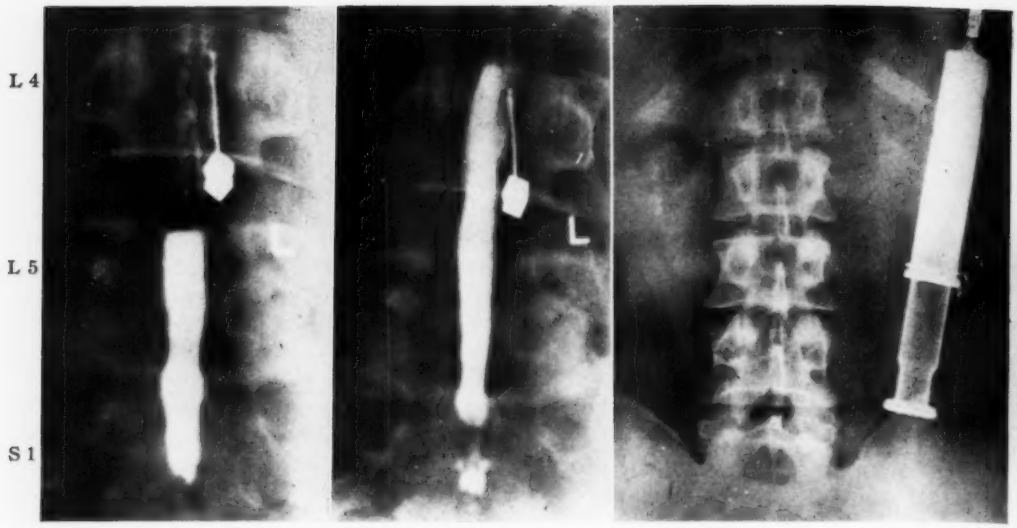

Fig. 1. Demonstration of the changes in the column of opaque oil produced by increasing the intraspinal pressure during the Valsalva maneuver to remove the oil at the completion of x-ray examination. The column of Pantopaque during the Valsalva experiment is narrowed; it moves cephalad a distance of about 2.0 cm., and it is lengthened in the longitudinal axis. The spinal fluid, being lighter and more fluid, is moved away from the heavier oil. In this way the oil under pressure is brought into intimate contact with the needle and will bubble out of it without the use of a syringe and forced suction. For case report see foot of opposite page.

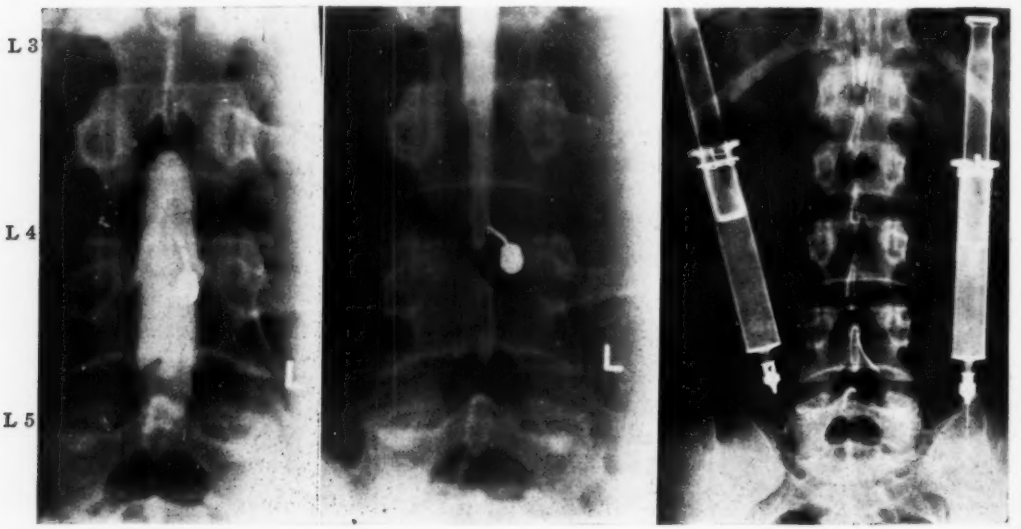

Fig. 2. In some patients extreme changes occur in the movement of the oil column with variations in the intraspinal pressure. This patient was very restless and apprehensive throughout the radiographic examination. During the Valsalva maneuver there was a marked cephalad movement of the oil column, the total shift being 5 to 6 cm. The movement was very fast. The oil would shoot past the needle with very little bubbling out. It is interesting that in all cases the oil column always moved cephalad even when the patient was almost erect. Furthermore, with the patient in a 60° erect position and the oil column flowing caudad, a sudden forced expiration against the closed glottis would stop the downward course of the oil and cause it to move cephalad. Lack of cooperation rather than the extreme movement of the oil was the cause for the failure to remove the oil in this case. For case report, see foot of opposite page.

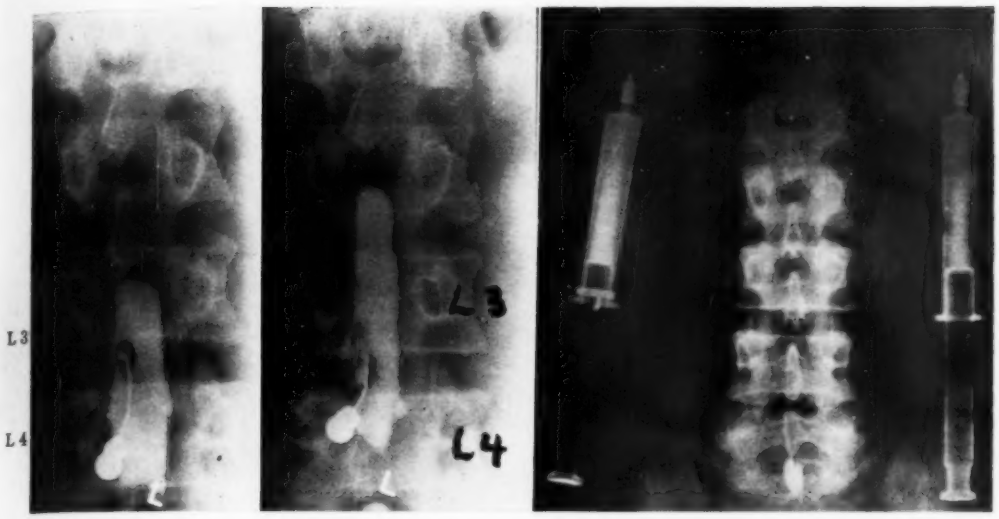

Fig. 3. Pantopaque is a satisfactory contrast medium for the routine localization of protruded disks, especially since it can be removed by utilizing physiological mechanisms for increasing the intraspinal pressure.

CASE 3: F. A. S., water tender, second class, age 33, suffered attacks of "lumbago" during the past four years. In the last four months there had been a gradually increasing back pain accompanied by right sciatic pain. These pains were aggravated by sneezing and coughing. The ankle jerks were equal, but there was hypesthesia over the lateral aspect of the right leg. During the myelographic examination a protruded disk was found between the third and fourth lumbar vertebrae on the right. The patient was operated upon, with relief of symptoms, and returned to duty.

necessary, but it puts the patient at ease and makes him more co-operative. The lumbar puncture is done with the patient lying on his side. The needle should be inserted squarely into the center of the spinal canal to facilitate the removal of the oil. When the needle is in the proper position, the spinal fluid flows out freely. Three cubic centimeters of fluid are then removed and 3 c.c. of Pantopaque are injected. The stilette is replaced in the needle and the patient turns over on his stomach and stretches out on the radiographic table. The lumbar puncture needle remains in place throughout the examination.

The usual fluoroscopic study of the lumbar subarachnoid space is carried out, the patient being tilted slowly up and down so that the oil is retained in a single mass and flows over each disk in the prone and in both oblique positions. A spot-film device is used, and instantaneous exposures are made of all filling defects or those even faintly suspicious.

At the completion of the radiographic examination the patient remains in the prone position and the craniad portion of

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CASE 1 (Fig. 1): J. P., seaman, second class, age 24, six months prior to admission strained his back, lowering a boat. Shortly thereafter he began having right sciatic pain. Examination revealed a diminished right ankle jerk and hypesthesia over the lateral aspect of the right leg and foot. Myelography showed a definite but slight narrowing of the oil column opposite the fifth intervertebral disk. A ruptured disk was removed at operation and symptoms were relieved.

CASE 2: J. W. H., (Fig. 2): Marine private first class, age 23, had complained of pain in the low back and right hip at intervals for the past three years. It had been worse the past six months. The neurological and myelographic examinations were negative.

With this long history of back pain and apparent inability to perform his military duties, it was important to rule out the possibility of a protruded disk before transferring the man for medical treatment and ultimate discharge. Myelography in such cases can be helpful in ruling out malingering.

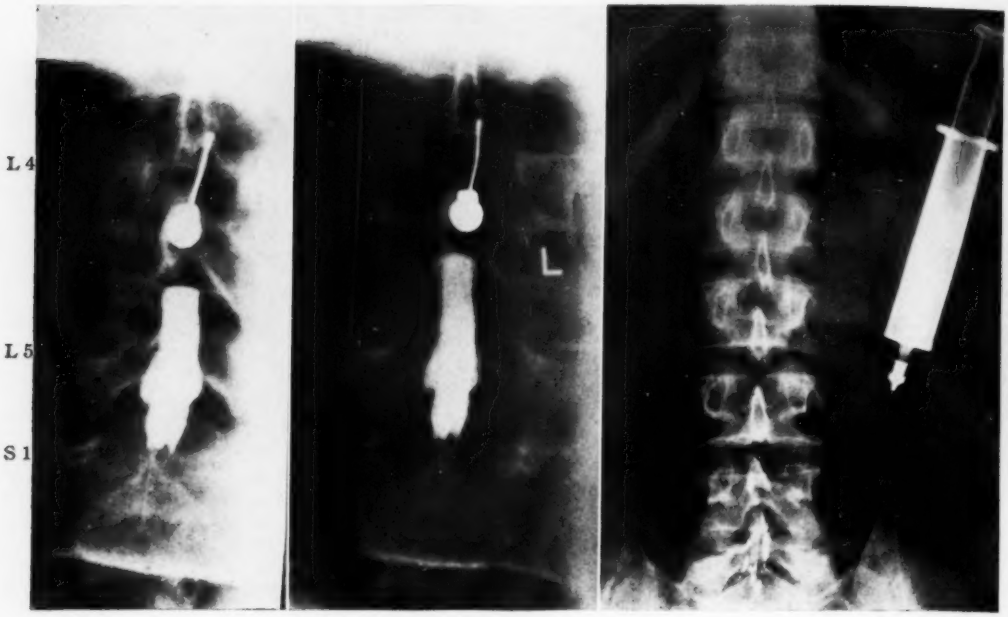


Fig. 4. Pantopaque is preferable to air in most instances for the detection of minor displacements of the axillary sheaths caused by protruded disks. The axillary sheath for the fifth lumbar nerve on the left is incompletely filled and is displaced slightly upward. This minor defect is often difficult to observe on air myelograms.

CASE 4: W. N. F., Marine corporal, age 24, had experienced a gradually developing pain in the low back and down the back of the left leg for the past four months. He received intensive orthopedic treatment, including a fasciotomy, without relief. The neurological examination was negative.

This case illustrates the point that the clinical diagnosis of protruded disks is not always easy and simple; otherwise the patient might have been spared the orthopedic measures. It indicates, also, that not all the physicians coming in contact with these patients possess the same superior background, experience, diagnostic acumen, and surgical skill.

the column of oil is flowed beneath the tip of the lumbar puncture needle. The stilette is removed and spinal fluid bubbles out of the needle. No syringe is attached to the needle and no effort is made to aspirate the oil by suction, since in so doing the nerve roots are frequently pulled against the needle and cause pain as well as block the exit of the oil. Instead, the patient is told to take a deep breath and to bear down as if he were attempting to move his bowels. This, of course, is Valsalva's well-known experiment of forced expiration against a closed glottis and has the effect of increasing the intraspinal pressure.

During the Valsalva maneuver, two things happen to the column of opaque oil: first, the whole column tends to move craniad a distance of from 0.5 cm. to as much as 5 to 8 cm.; second, the column becomes narrowed (Figs. 1–3). These changes are the result of an engorgement of the venous plexuses that surround the dura and can be demonstrated by taking spot films before and during forced expiration against the closed glottis. During the period of increased intraspinal pressure, the spinal fluid, which is very thin and lacks viscosity, is displaced, leaving the oil in more intimate contact with the tip of the needle so that it can be expelled. The oil comes bubbling out of the needle, usually in droplets interspersed with spinal fluid. The Valsalva maneuver is repeated as often as is necessary until all the oil is removed. As a rule, this is accomplished within twenty minutes, but occasionally it

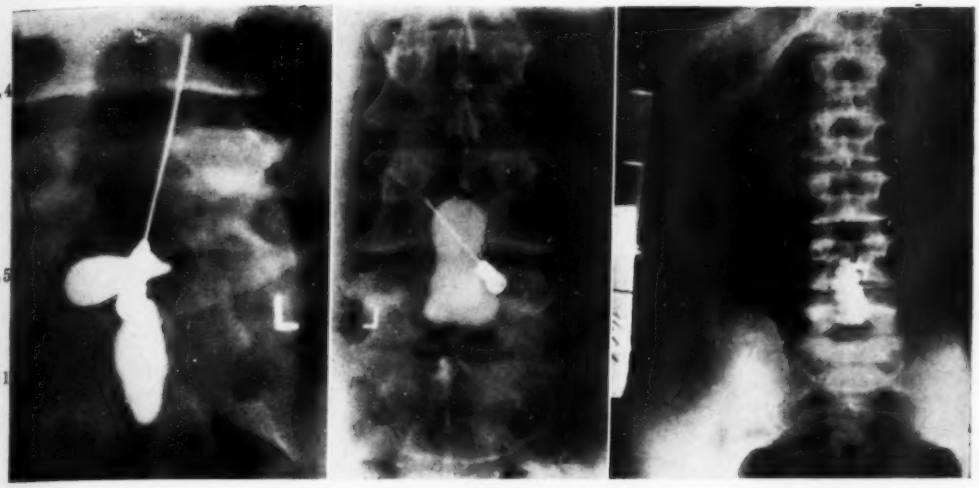


Fig. 5. Pantopaque myelography can be used to advantage when the clinical and neurological findings are not absolutely typical and air myelograms are not definite. In such cases myelography with Pantopaque can be a helpful factor in the detection of a protruded disk or the demonstration of normal disks to eliminate an exploratory operation.

CASE 9: J. F., chief machinist's mate, age 41. Air myelograms had been done previously in this case and had not afforded decisive information. On May 14, 1943, an exploratory laminectomy was done for a suspected ruptured disk. Both the fourth and fifth disks were examined, but no herniation of the nucleus pulposus or a protruded disk was found. The dura was opened and no tumor was seen. Later the patient was transferred to this hospital, still complaining of back pain, although the pain in his leg was almost entirely relieved. Examination revealed a decreased knee jerk and an area of hypesthesia over the region of the fourth lumbar dermatome.

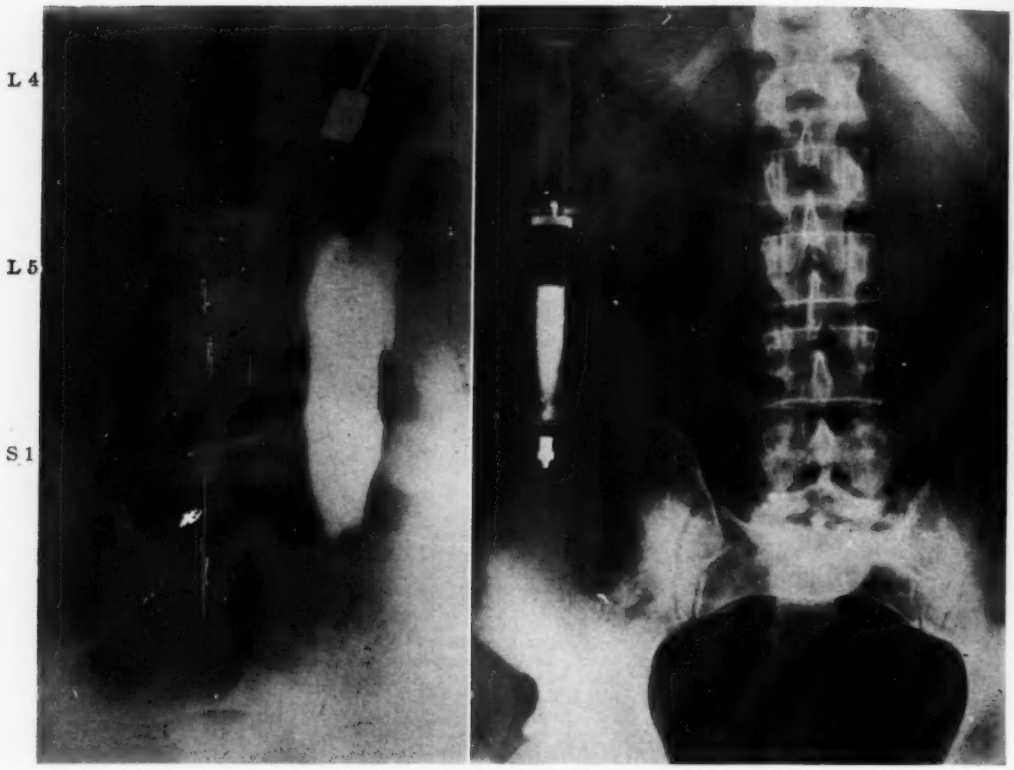
With Pantopaque as the contrast medium, a myelographic examination revealed a complete block of the subarachnoid space at the upper limits of the laminectomy and a narrowing at the lower limits due to postoperative adhesions. No disk changes were observed. Since no abnormal disk changes were found at operation and none during myelography, the disks can be considered normal. It is our opinion that the laminectomy might have been avoided by doing the myelographic examination first. This patient was subsequently referred to the orthopedic service for disposition.

This case is one of the few in which the oil was not successfully removed. The needle was accidentally and unknowingly pushed outside the space containing the oil, as is shown on the films.

may take as long as forty minutes. At intervals the patient is examined fluoroscopically and the table is adjusted to keep the diminishing oil column beneath the tip of the needle.

By this method we have been able to remove all but a few drops of the oil in every case in which any oil at all was expelled. Out of 50 cases we have had two failures. In one patient who had had a previous lumbar laminectomy with intradural exploration, there were intradural adhesions, and it was thought that they were responsible. On reviewing the films, however, it was discovered that the needle had been moved out of the subarachnoid space during the examination. The second failure was in a very uncooperative patient and was due to this cause rather than any other (Fig. 2). In the initial examinations the removal of the oil was not accomplished with the greatest of ease and required some persistence but, at that, we believe it is a simple, quick, and efficient method, while it has the added advantage that it does not cause the patient pain.

This brings us to the question: "Is contrast myelography necessary?" This is a pertinent inquiry, particularly in view of the opinion of some (4, 5) that it is not necessary and should be dispensed with. Basically, this difference of opinion can be explained by the fact that not all surgeons specializing in this field have the same background, experience, diagnostic acu-



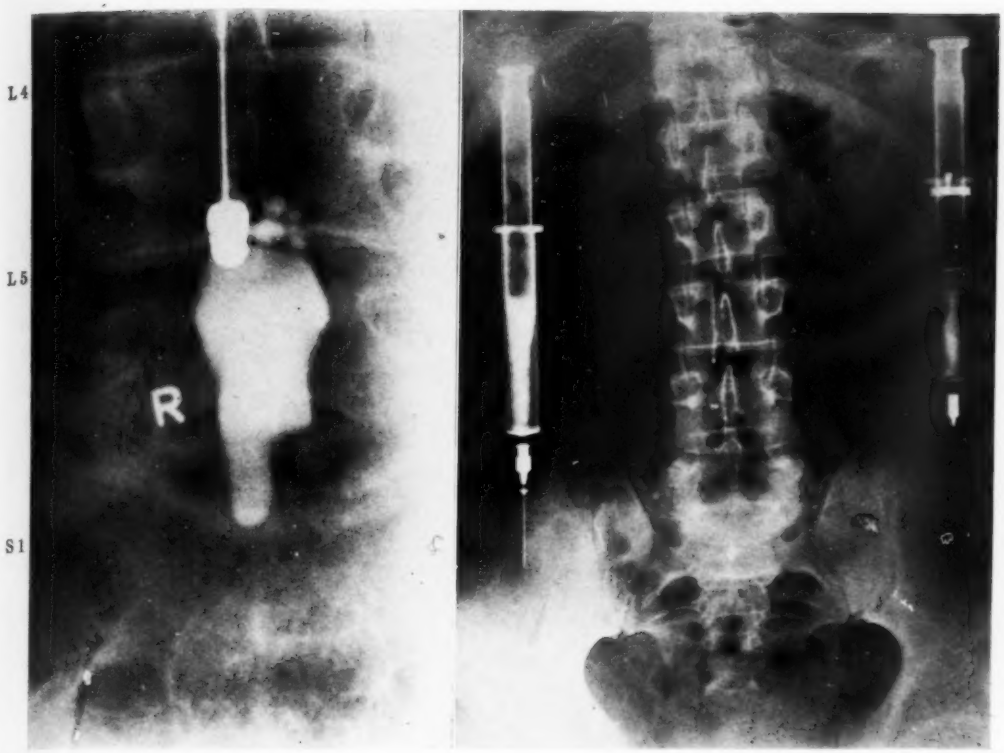
Relaxed After Removal

Fig. 6. Myelography can be used to rule out protruded disks in patients with sciatic pain before they are submitted to orthopedic surgery.

CASE 6: O. J. M., seaman, second class, age 35, had for two months experienced a knife-like pain radiating down the back of the right leg from the hip. Sneezing or coughing aggravated the pain. Walking or work also produced it. There were periods of complete freedom when the patient was lying down or was not required to work. Neurological examination was negative. Routine radiographic examination revealed a lumbarization of the sacrum on the left, which is a common congenital anomaly. It probably bore no relationship to the back pain. Myelography was negative. The patient was transferred to the orthopedic service for spinal fusion because of incapacitating pain

men, or surgical skill. We do not believe that it is necessary to do myelographic examination in cases that are definite and clear cut. One neurological surgeon (3) estimates that this group constitutes about 60 per cent of the patients with intraspinal protrusions of the lumbar disks. Even at this time, however, the clinical signs of intraspinal disk protrusion are not always so characteristic as to warrant operation without objective and confirmatory myelographic evidence. Myelography then should be used in much the same way as radiographic examination with other contrast media, such as ventriculography, bronchography, pyelography, cholecystography, etc. In other words, if the indications for operation are so convincing that the surgeon can assume full responsibility for the accuracy of his findings, myelography is not necessary. On the other hand, many men prefer some support from an objective examination before submitting their patients to major surgery. At the present time we feel that there is a practical method for myelographic examinations, although the future will undoubtedly bring greater refinements and newer contrast media (Figs. 3–6).

Another indication for myelography is in



Relaxed After Removal

Fig. 7. Persistence or recurrence of pain after an operation for the removal of a disk is an indication for myelography to detect a recurrence or an incomplete removal of the disk. By contrast myelography in such instances, it is usually possible to determine if the disk was completely removed, if it recurred, or if another disk has protruded. It is even more important to do a myelographic examination if none has been previously performed.

CASE 8: R. B., Marine sergeant, age 28, had been operated on elsewhere in November 1942, with an interlaminar removal of a ruptured disk between the fifth lumbar vertebra and the sacrum. His symptoms were somewhat improved for a time but recurred. He complained of low back pain which radiated down the left leg. The left ankle jerk was absent and hypesthesia was present over the lateral aspect of the left leg. Myelographic examination with Pantopaque revealed a defect at the fifth disk on the left, with obliteration of the axillary sheath. At the second operation the remainder of the disk was found and removed. The symptoms gradually subsided and the patient returned to active duty.

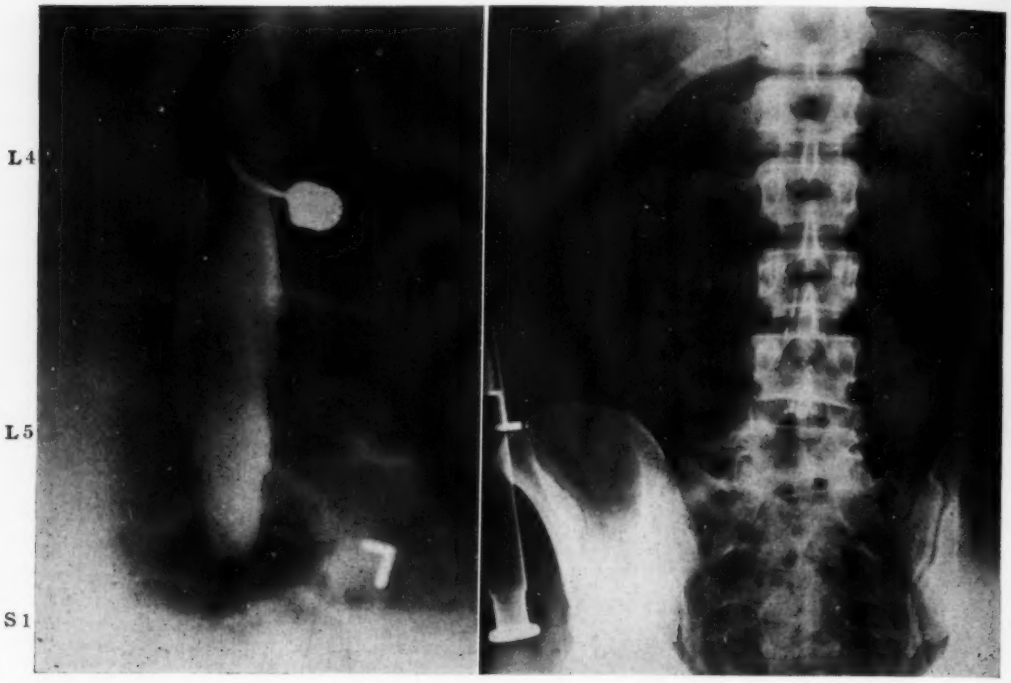
the examination of patients who have a persistence or a recurrence of back pain following an operation for a protruded disk. In these cases myelography is of value to determine if the pain is due to incomplete removal of the operated disk, to a recurrence, or protrusion of another disk at a different level (Fig. 7).

Similarly, a myelographic examination is of value to demonstrate negative or normal disks in patients with recurrence or persistence of pain after an operation for a protruded disk. Objective radiographic evidence will greatly aid in the subsequent treatment and disposition of these patients. This is particularly true in the handling of industrial cases, as well as those in the Armed Services (Fig. 8).

Myelography is also helpful in the positive identification of multiple protruded disks and gives the surgeon aid in localizing the herniated disks and in sparing many patients unnecessary exploration of normal disks (Fig. 9).

SUMMARY AND CONCLUSIONS

1. Pantopaque is a satisfactory contrast medium for spinal myelography.



Relaxed After Removal

Fig. 8. Myelography is of value to demonstrate negative or normal disks in patients with recurrence or persistence of pain after an operation for a disk. This is particularly important in industrial and military practice, where the patient may wish to prolong or exaggerate his pain and degree of disability.

CASE 8: E. S. T., Marine corporal, age 34, began in April 1943 to complain of low back pain which radiated down the left leg. The pain gradually increased in frequency and intensity. It was aggravated by sneezing and coughing. Various types of treatment were given without permanent relief. Neurological examination revealed a hypesthesia over the lateral aspect of the left leg and the base of the great toe. The diagnosis of a ruptured disk between the fifth lumbar vertebra and the sacrum on the left was made. On Jan. 21, 1943, the ruptured disk was removed by the interlaminar method. The patient's condition improved and he was returned to active duty on April 21, 1943. He was readmitted on May 29, 1943, complaining of backache and slight leg pain. Myelography with Pantopaque was negative, and all the oil was easily removed without discomfort. With this information plus the knowledge that there were no postoperative complications, it was possible to transfer the patient to the orthopedic service for a few manipulative and physical therapy treatments, which were followed by prompt return to duty.

In our experience, it is the most satisfactory one to date. It seems to produce no unfavorable reactions and is removed from the spinal canal without difficulty.

2. A new procedure is described for the removal of Pantopaque after completion of the radiographic examination, by methods designed to increase the intraspinal pressure rather than by use of a syringe with positive suction. By this means it has been possible to remove all but a few drops of the oil, without pain to the patient.

3. The value and use of myelographic examinations are discussed and cases are presented to illustrate the indications both before and after operative procedures for protruded disks.

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Seattle, Wash.

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Relaxed Oblique View After Removal

Fig. 9. Myelography is of value in the recognition of multiple protruded disks or other lesions. The detection of multiple protruded disks makes it possible for the surgeon to know just what disks must be examined and removed. Likewise, the finding of normal disks by myelography and the accurate visualization of the protruded disk eliminate needless exploration of normal disks.

CASE 7: D. L. H., carpenter's mate, third class, age 41, experienced a gradual onset of pain in the back and down the left leg five months before admission. Pain was aggravated by coughing and sneezing. Orthopedic measures gave no relief. The left ankle jerk was reduced and hypesthesia was found along the lateral aspect of the left leg from the knee to the ankle. Following operation for the removal of the disk, symptoms disappeared.

The large defect between the third and fourth lumbar vertebrae was originally thought to be due to a disk, but at operation was found to be the result of large veins. The lower defect proved to be a protruded disk.

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Radiation Therapy of Lymphoid Tissue in the Nasopharynx and Pharynx

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DURING THE FIVE-YEAR interval between 1939 and 1943 inclusive, 157 patients were treated with roentgen rays and/or gamma rays for the removal of lymphoid tissue in the nasopharynx and pharynx. Of these patients, 86 (55 per cent) were males and 71 (45 per cent) females. The greatest incidence occurred in the first decade, with an even spread in middle age and a rapid decline above the fifth decade. Approximately one-third of the patients were less than fifteen. The youngest was nine months; the oldest, seventy-eight years. The distribution of cases was as follows: up to nine years of age, 44 (28 per cent); ten to nineteen years, 24 (15.2 per cent); twenty to twenty-nine, 29 (18.6 per cent); thirty to thirty-nine, 25 (15.9 per cent); forty to forty-nine, 19 (12.1 per cent); fifty to fifty-nine, 10 (6.3 per cent); sixty to sixty-nine, 4 (2.5 per cent); seventy to seventy-nine, 2 (1.2 per cent).

Symptoms fell into three main classes. In the group of 27 cases (17 per cent of the series) which presented demonstrable hearing losses, audiograms were obtained whenever possible. Fifty-one patients (32 per cent) had lymphoid masses large enough to obstruct respiration, as was evidenced by mouth breathing. Almost all of the patients (144, or 92 per cent) had some form of upper respiratory infection, such as pharyngitis, otitis media, sinusitis, tonsillitis, etc. In this group, 13 of the children had acute cervical adenitis; 8 had otitis media; 3 had acute rheumatic fever; 4 had asthma.

The amount of lymphoid tissue present was classified on an arbitrary basis from one to four plus. One plus represents a minimal amount of tissue, usually in the form of small flecks over the mucous membranes. Two plus represents a more noticeable amount, but not sufficient to cause obstruction; three plus means sufficient lymphoid tissue to cause mouth breathing. Four plus is reserved for those cases where the tonsils meet in the mid-line or where the nasopharynx is so choked with adenoids that little, if any, air space remains. Sixteen cases, or 10 per cent, were classified one plus; 90, or 57 per cent, two plus; 36, or 23 per cent, three plus; the remaining 15 (10 per cent) fell in the four plus group.

The first cases in this series were treated with extremely conservative amounts of radiation, as it is believed that in the treatment of benign conditions there is seldom justification for the production of erythemas or other permanent radiation side effects. Aside from temporary dryness of mouth, which is an occasional minor complaint, no such effects have been noted. By proceeding slowly and cautiously, it was found that the average patient could tolerate without untoward effects 800 to 1,200 tissue roentgens, administered to the nasopharynx and pharynx within a period of four to five weeks. The dosages employed are shown in Table I. The results obtained were good. This dosage was very satisfactory for young children; but in older children and adults, it did not always completely clean out the lymphoid tissue from the nasopharynx.

Hence, an applicator was devised by means of which 25 mg. of adequately filtered (1.0 mm. platinum) radium could be introduced into the nasopharynx through each naris. By leaving the radium in place for one and one-half hours, a dose of 75 mg. hr. is delivered, and this has been selected as standard dosage in almost all cases. No unfavorable reaction has been produced by this proce-

[1] Read by title at the Twenty-ninth Annual Meeting of the Radiological Society of North America, Chicago, Ill., Dec. 1–2, 1943.

TABLE I: ROENTGEN DOSAGE IN CASES NOT RECEIVING GAMMA RADIATION

Tissue Roentgens	Cases
0– 99	0
100– 199	0
200– 299	5 (5.1%)
300– 399	3 (3.0%)
400– 499	3 (3.0%)
500– 599	4 (4.0%)
600– 699	4 (4.0%)
700– 799	1 (1.0%)
800– 899	15 (15.3%)
900– 999	17 (17.3%)
1000–1099	15 (15.3%)
1100–1199	17 (17.3%)
1200–1299	4 (4.0%)
1300–1399	5 (5.1%)
1400–1499	1 (1.0%)
1500–1599	0
1600–1699	2 (2.0%)
1700–1799	0
1800–1899	1 (1.0%)
1900–2000	1 (1.0%)
TOTAL	98

dure, and it has been possible with this supplementary radiation to reduce the roentgen tissue dosage and obtain a superior end-result. The cases treated by the combination of roentgen and gamma rays are tabulated in Table II, where it is seen that only 8 out of 62 cases required over 1,000 tissue roentgens.

From these studies the following basic procedure has been evolved: Within a period of twenty-nine days, the patient receives three pairs of roentgen-ray treatments, a radium treatment, and two more pairs of roentgen-ray treatments. Two treatments are given in the first week, and the remaining ones are administered at weekly intervals. In other words, the patient receives x-ray treatments on the first, fourth, eighth, twenty-second and twenty-ninth days and a radium application on the fifteenth day. The physical factors employed are 200 kv.p., 60 cm. target-skin distance, 0.5 mm. copper filter, 10 cm. diameter round cone, 125 r (as measured in air) to each of two ports, one on each side of the face and neck. In selecting the ports, the central beam is directed perpendicularly to the sagittal plane of the head with the upper edge of the treatment cone tangent at the external auditory canal to an imaginary horizontal plane passing through the canal. The radium treatment, as previously noted, consists of 75 mg. hr. in the nasopharynx. Figure 1 is a typical therapy chart. When more roentgen therapy is required than is delivered by this basic technic, the additional radiation should be administered perorally, rather than by increasing the dosage through the lateral ports which have been described. A dose of 1,000 skin roentgens (back-scatter included) is considered the safe upper limit for any single port.

TABLE II: ROENTGEN DOSAGE IN CASES RECEIVING GAMMA RADIATION*

Tissue Roentgens	Cases
0– 99	2 (3.2%)
100– 199	0
200– 299	1 (1.6%)
300– 399	0
400– 499	0
500– 599	2 (3.2%)
600– 699	3 (4.8%)
700– 799	2 (3.2%)
800– 899	32 (51.6%)
900– 999	12 (19.3%)
1000–1099	3 (4.8%)
1100–1199	1 (1.6%)
1200–1299	1 (1.6%)
1300–1399	1 (1.6%)
1400–1499	1 (1.6%)
1500–1599	0
1600–1699	0
1700–1799	0
1800–1899	0
1900–2000	1 (1.6%)
TOTAL	62

* The discrepancy in the number of cases listed in Tables I and II (160 rather than 157) is due to the fact that 3 cases were retreated.

During the course of this work, numerous impressions have been formed. These impressions we believe will be confirmed with further experience. The gratifying results obtained in the treatment of conduction deafness in children are outstanding. Two illustrative cases follow:

CASE I: N. H., white male, aged eleven years, was referred by Dr. S. L. Fox on June 19, 1943. The tonsils had been removed previously. Both eustachian orifices were completely obliterated by lymphoid tissue, which extended down the posterior pharyngeal wall. The patient showed considerable hearing loss, as was demonstrated on the audiogram of June 15. Between June 19 and Aug. 23 (sixty-six days) the patient received 1,920 tissue roentgens, and on July 13 he received 75 mg. hr. of radium. By the middle of September, hearing was relatively

CALIBRATED PHYSICAL FACTORS

TECH	DESCRIPTION OF APPARATUS	kv	FILTRATION			hvl mm	ma	BEAM SIZE	DIST. cm	r/m AIR
			INHERENT	ADDED	TOTAL					
C	Oil tube; Villard circuit	200	0.25 Cu	0.5 Cu	0.75 Cu	.9Cu	15	4x4	60	24.2

DAILY RECORD OF TREATMENT

DAY	DATE 1943	TECH	REGION TREATED	FIELD SIZE	fad cm	min	r AIR	QUANTITY ON SKIN r/m	FIELD r	EXIT r	TOTAL r	QUANTITY ON DISEASE %	r/m	DAY r	TOTAL r
1	10-19	C	Lt. neck	10 cm. cone	60	5	121	32	161	28	189	53	17	85	85
1	10-19	C	Rt. neck	10 cm. cone	60	5	121	32	161	28	189	53	17	85	170
4	10-22	C	Lt. neck	"	60	5	121	32	161	28	378	53	17	85	255
4	10-22	C	Rt. neck	"	60	5	121	32	161	28	378	53	17	85	340
8	10-26	C	Lt. neck	"	60	5	121	32	161	28	567	53	17	85	425
8	10-26	C	Rt. neck	"	60	5	121	32	161	28	567	53	17	85	510
22	11-9	C	Lt. neck	"	60	5	121	32	161	28	756	53	17	85	595
22	11-9	C	Rt. neck	"	60	5	121	32	161	28	756	53	17	85	680
29	11-16	C	Lt. neck	"	60	5	121	32	161	28	945	53	17	85	765
29	11-16	C	Rt. neck	"	60	5	121	32	161	28	945	53	17	85	850

Fig. 1. Typical therapy chart.

normal. The latest audiogram, Dec. 4, 1943, demonstrates this improvement (Fig. 2).

CASE II: V. K., white female, aged ten years, was referred by Dr. F. A. Kayser on Oct. 1, 1943. The patient was deaf enough to require a hearing aid constantly and to attend a school for deaf children. There was sufficient lymphoid tissue in the nasopharynx to obstruct breathing and obscure the eustachian orifices. The tonsils and adenoids had been removed, but they had recurred, and the child had a long history of upper respiratory infection. Between Oct. 1 and Oct. 30 (twenty-nine days) she received 950 tissue roentgens and a radium treatment of 75 mg. hr. By the middle of November she had discarded the hearing aid and could hear easily when seated on the back row in the school room. On Jan. 8, 1944, Dr. Kayser reported the hearing to be normal. The lymphoid tissue showed complete regression, mouth breathing had stopped, and there was no infection present. The improvement in the child's general appearance was remarkable.

Equally gratifying have been the results in those children who suffer principally from respiratory obstruction and infection. Two more typical case histories follow:

CASE III: C. G., white male, aged five years, was referred by Dr. T. F. Daniels with a diagnosis of acute follicular tonsillitis and acute bilateral cervical adenitis. Sulfadiazine had been administered without favorable results. X-ray therapy was initiated on July 31 and completed on August 21, 1,143 tissue roentgens constituting the dosage. No radium was used. The child made a rapid and uneventful recovery. On Jan. 15, 1944, there was no evidence of residual lymphoid tissue, and there were no symptoms.

CASE IV: J. S. H., Jr., white male, aged six years, was referred by his father, Dr. J. S. Harding. The patient had an almost continuous coryza with postnasal drip, cough, slight deafness, and mouth breathing. The amount of lymphoid tissue present was three plus, and x-ray examination of the nasal sinuses demonstrated marked opacity of the right ethmoids and antrum. Between Nov. 5 and Dec. 5, the patient received 1,015 tissue roentgens without radium therapy. By Jan. 9, 1943, all symptoms had disappeared, and the sinuses were normal to x-ray examination.

In the treatment of adults, as in children, the rationale of the procedure is based on the destruction of lymphoid tissue. Therefore, if sinus disease is due to obstruction of the ostia by lymphoid tissue, good results can be expected. In several instances, chronic suppurative tonsillitis has been treated in old people with suffi-

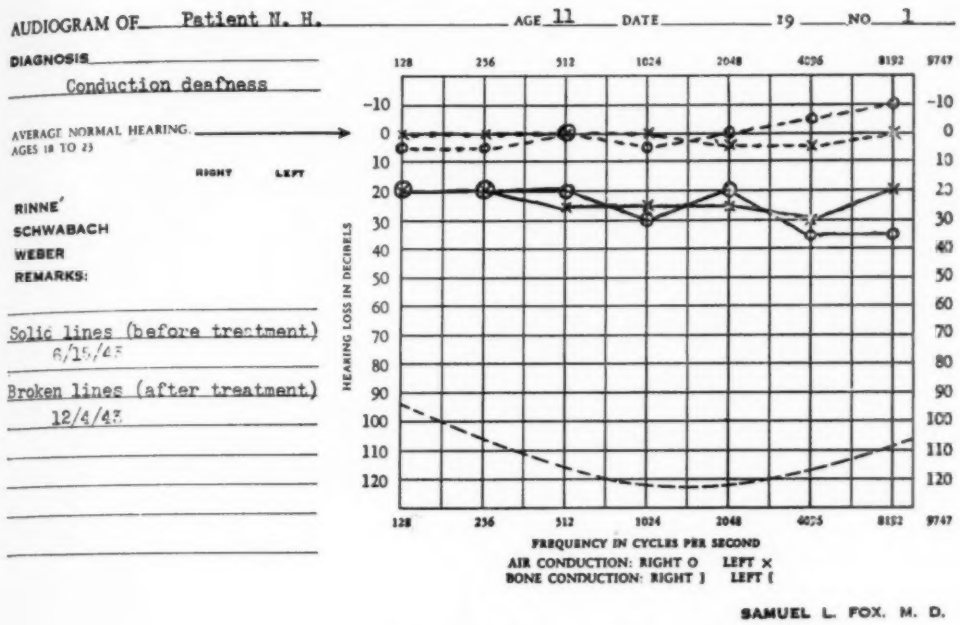
AUDIOGRAM OF Patient N. H. AGE 11 DATE 19 NO. 1
DIAGNOSIS
Conduction deafness
AVERAGE NORMAL HEARING AGES 18 TO 25
RIGHT LEFT
RINNE'
SCHWABACH
WEBER
REMARKS:
Solic lines (before treatment) 6/15/47
Broken lines (after treatment) 12/4/47
128 256 512 1024 2048 4096 8192 9747
-10 0 10 20 30 40 50 60 70 80 90 100 110 120
HEARING LOSS IN DECIBELS
FREQUENCY IN CYCLES PER SECOND
AIR CONDUCTION: RIGHT O LEFT X
BONE CONDUCTION: RIGHT] LEFT [
SAMUEL L. FOX, M. D.

Fig. 2. Case I: Audiograms before and after treatment

cient cardiac disease to contraindicate surgery. Results to date have been satisfactory. It has been observed that, as a general rule, lymphoid tissue becomes less radiosensitive with age, and also less sensitive in the presence of prolonged suppurative infection. In such cases larger doses must be given to obtain satisfactory results. For this reason, cases presented for treatment should have a careful examination, including nasopharyngoscopy, to determine those most suitable for the method of treatment described. If such care is exercised, the results will leave little to be desired. The full effect of the irradiation is not ordinarily noted until from six to eight weeks after the final treatment. This period may be shorter in the case of young children and longer in the case of adults with chronically infected lesions.

SUMMARY

Over a five-year period, 157 patients were treated with radiation for lymphoid tissue in the nasopharynx and pharynx. The procedure is believed to be practical, efficacious, and efficient.

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Roentgen Treatment of Lymphoid Tissue in the Nasopharynx[1]

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SINCE CROWE and Baylor (1) pointed out the relationship existing between hypertrophied lymphoid tissue in the nasopharynx and impaired hearing, advocating the use of radium, several papers (2–7) have been written discussing radium therapy, but little mention has been made of roentgen irradiation. Although the number of patients afflicted is not great, the disability resulting from deafness is so tragic that we should all be familiar with the treatment of this condition. As every radiologist does not have radium available, it seems advisable to point out that roentgen therapy is safe and effective.

Excessive lymphoid tissue in the nasopharynx is common in infancy and childhood. It occurs also in adults, but less frequently. When the hypertrophy is particularly prominent on the lateral walls, obstruction to the nasopharyngeal orifice of the eustachian tube is produced. If allowed to persist or increase, this results in impaired hearing. This appears first in the high tones. Long-standing obstruction causes progressive deafness which ultimately affects the low tones, also. If the obstruction is relieved early, the hearing will return to normal.

Most of these patients are discovered during school examinations because of impaired hearing; some are found by the rhinologist; a few are brought to the otologist because of increasing deafness or speech defects. If impaired hearing and hypertrophied lymphoid tissue obstructing the eustachian tubes are found, treatment, either by irradiation or surgery or both, is indicated. Surgical removal of adenoids around the eustachian tubes is difficult and often incomplete. On occasion, surgical removal of the central masses is indicated, followed by irradiation for the lateral masses.

The objective of roentgen-ray treatment is to deliver between 700 and 800 tissue roentgens to the tissues on each lateral wall of the nasopharynx, in divided doses, within eight days. Originally a dose of 600 tissue r was used, but failure was frequent and recurrence common. Since the dose has been raised to the present level, between 700 and 800 tissue r, the lymphoid tissue masses have disappeared in every case, and in only 2 out of 26 cases has there been a recurrence.

Two direct lateral fields are used, centering over the nasopharynx. In children six years of age or less, a circular field with a diameter of 4 cm. is used. In all patients over six a circular field 5 cm. in diameter is used. The factors are 200 kv., 0.5 mm. Cu plus 1.0 mm. Al filter, half-value layer 0.8 mm. Cu.

In the average child of seven the thickness laterally through the nasopharynx is 12 cm. If 800 r, measured in air, are given into each lateral area, each lateral wall of the nasopharynx will receive a total of 780 tissue r. Each skin area will receive 1,104 tissue r, including the exit dose. This dose may be conveniently divided into four treatments, consisting of 200 r (in air) into both fields on alternate days.

No unfavorable reaction has been noted. A few patients report a slight dryness of the nasopharynx. One interesting subjective phenomenon was reported by an intelligent boy of eleven. He claimed that during the irradiation he detected an unidentifiable odor, neither pleasant nor unpleasant. Efforts were made to convince him that this was imaginary, but without success.

Twenty-six patients have been treated with this technic and have been followed for two years. In 8 of these the hearing

[1] Read before the Twenty-ninth Annual Meeting of the Radiological Society of North America, Chicago, Ill., Dec. 1–2, 1943.

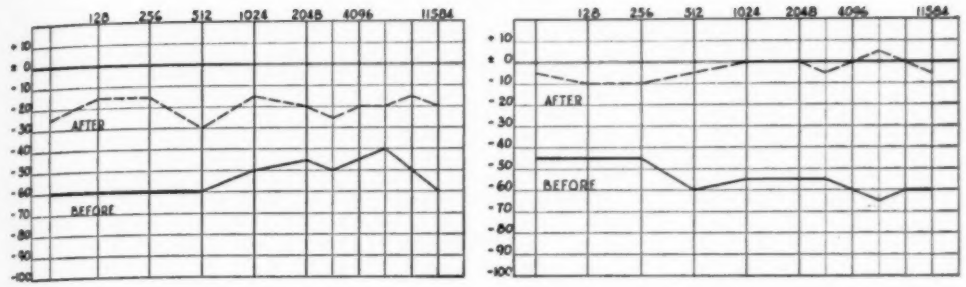

Fig. 1. Audiograms for both ears, showing hearing before and six weeks after treatment. The ordinate scale is in decibels; the abscissa in frequency. The patient was twelve years old. She had had discharge from both ears for one year. Deafness had been noticeable for ten months. Both ear drums were scarred, thickened, and retracted. The nasopharyngeal opening of each eustachian tube was covered by a large mass of lymphoid tissue. After treatment the lympoid tissue disappeared entirely. (I am indebted to F. W. Davison, M.D., for the audiograms.)

was normal but there was hypertrophied lymphoid tissue in the nasopharynx producing nasal obstruction or retraction of the ear drums or both. The treatment was successful in removing the lymphoid tissue in every case, and also in relieving the nasal obstruction and allowing the ear drums to return to normal position. In 2 patients there was a recurrence of the lymphoid tissue after approximately six months. A second course of treatment resulted in permanent relief.

Eighteen of the patients had some impairment of hearing plus excess lymphoid tissue. The lymphoid tissue disappeared in every case, and in 17 there was improvement of hearing as measured by an audiometer. A change of less than 20 decibels was not regarded as significant. In only two instances did the hearing return to normal. This is not surprising, as these patients had had trouble for long periods of time, from one to many years, with repeated attacks of "running ears." These attacks of suppuration produce irreversible cicatricial changes so that restoration of normal hearing cannot be expected. It is important to discover and treat these patients early to avoid permanent hearing loss.

Figure 1 presents the audiograms from a typical case before and six weeks after treatment.

SUMMARY

Hypertrophied lymphoid tissue in the nasopharynx is a common cause of deafness. It may be successfully removed by irradiation with roentgen rays, as well as radium. If treatment is instituted before permanent changes have occurred in the ear, the hearing may return to normal.

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A Quantitative Study of the Effect of Temperature on Sensitivities of X-Ray Screens and Films[1]

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IT IS WELL KNOWN that the brilliance of fluorescent screens and the speed or sensitivity of radiographic films are affected by changes in temperature. Although these phenomena have been of little more than academic interest in the past, they have recently assumed new importance because of the varied climatic conditions under which radiological examinations are conducted in the military services.

The relationship between temperature and the brilliance of a fluorescent material is relatively simple (1, 2). At very low temperatures fluorescent emission is low but it rises rapidly as temperature increases and reaches a maximum at a point depending upon the chemical composition of the material. Beyond this point the emission gradually decreases and falls again to very low levels at high temperatures. Calcium tungstate screens fluoresce most brilliantly at about −100° C. At room-temperature (25° C.) their emission is approximately 35 per cent less than maximum and diminishes steadily as temperature is increased. The temperature of maximum brilliance for zinc sulfide (fluorazure and photoroentgen) and for zinc cadmium sulfide (type "B" fluoroscopic) screens is at or near room-temperature. The emission of these materials changes only slightly when temperature is increased or decreased as much as 100° C.

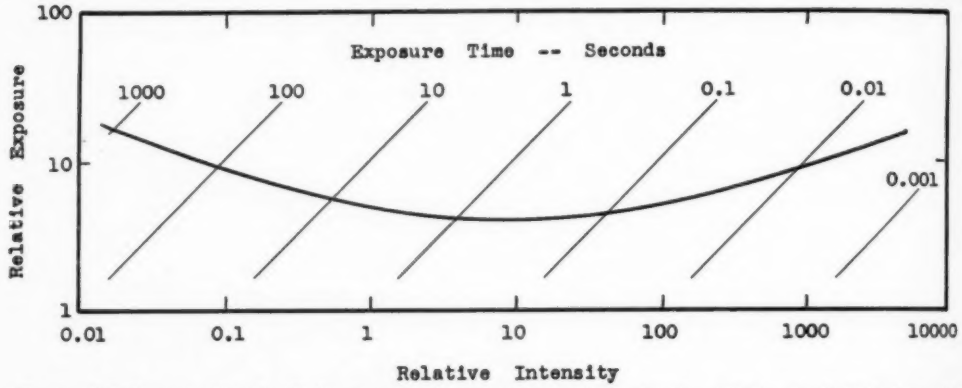


Fig. 1. Relative quantity of radiation (exposure) required to produce a density of 1.0 in a typical photographic film at various levels of intensity. Diagonals indicate the exposure times which were employed at the various levels of intensity.

The effect of temperature on the speed or sensitivity of radiographic films is dependent on the method of exposure. Films exposed with roentgen rays directly exhibit a slow rise in sensitivity as temperature increases (3). The behavior of films exposed with intensifying screens is more complex. Since almost all of the blackening produced in films exposed in this manner is the result of fluorescent radiation lying within the visible spectrum, such films react to temperature in much the same way as photographic materials. Webb (4) has shown that this reaction is closely related to the phenomenon of reciprocity law failure.

[1] From the Division of Roentgenology, University of Chicago. The work described in this paper was done under a contract recommended by the Committee on Medical Research, between the Office of Scientific Research and Development and the University of Chicago. The paper was read by title at the Twenty-ninth Annual Meeting of the Radiological Society of North America, Chicago, Ill., Dec. 1–2, 1943.

The reciprocity law states, among other things, that a particular quantity of radiation always produces the same photographic effect regardless of the intensity[2] of the exposing radiation. It long has been recognized that photographic films do not in general fulfill this law, and it has recently been shown that the law is also violated by radiographic films exposed with intensifying screens (5). Relatively large quantities of radiation are required to produce a given photographic or radiographic effect when the intensity of the exposing radiation is low. As intensity increases, the amount of radiation required decreases and reaches a minimum near the intensity level commonly employed in general radiography. When intensity is increased still further, the necessary quantity of radiation increases and rises again to high values at high intensity levels. A curve illustrating the relative quantities of radiation required to produce a film-density of 1.0 (approximately the average density of a correctly exposed film) in a typical photographic emulsion at various levels of intensity is shown in Figure 1. Such a curve is usually referred to as a reciprocity-law-failure curve. The exposure times corresponding to the various intensity levels are indicated by the diagonals.

Webb (4) has observed that changes in temperature cause a shift in the reciprocity-law-failure curve of a film in the direction of the intensity-axis. Increasing temperature effects a shift to the right, whereas decreasing temperature causes a shift to the left. These observations are illustrated in Figure 2, where the quantities of radiation required to produce a film-density of 1.0 in a typical radiographic film exposed with intensifying screens are plotted through a wide range of intensity at three temperature levels.

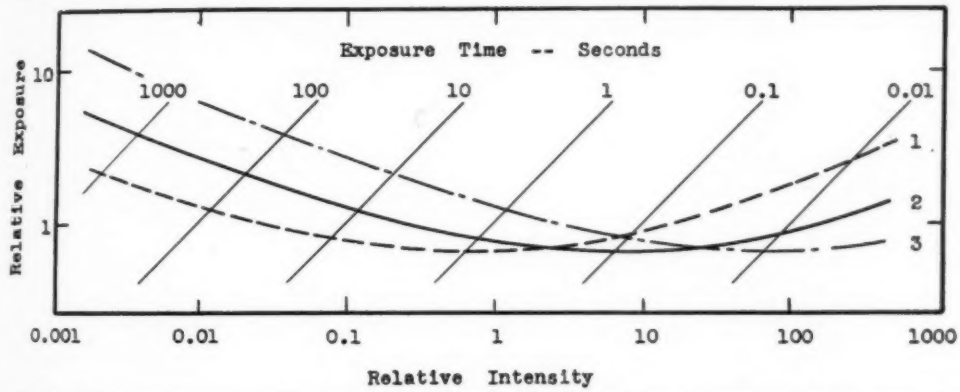


Fig. 2. Relative exposures required to produce a density of 1.0 in a typical radiographic film exposed with intensifying screens at various levels of intensity. Curve 1 was prepared from data made at −10° C. Curves 2 and 3 correspond to temperature levels of 25° and 60° C., respectively.

The speed or sensitivity of a radiographic film may best be expressed as the reciprocal of the quantity of radiation (exposure[3]) required to produce a film-density of 1.0; that is,

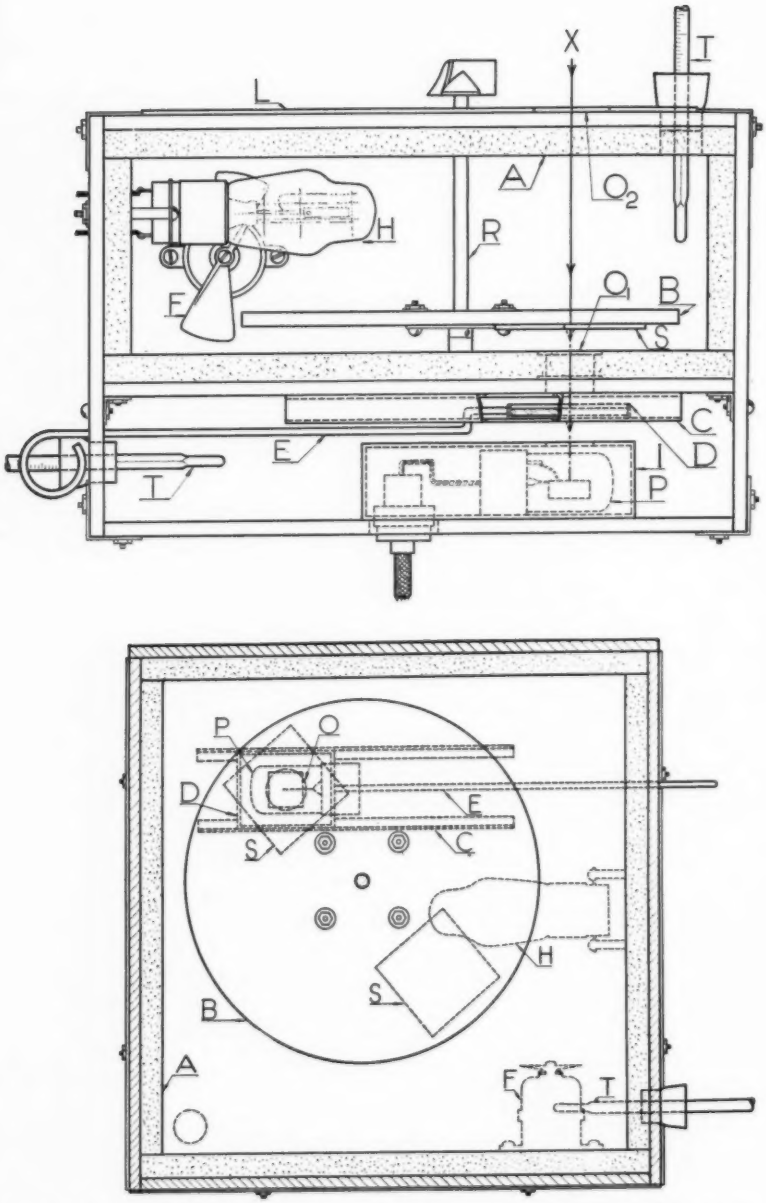
$$s_e = \frac{d}{E_{1.0}} \qquad (1)$$

where s_e is the speed of the film, $E_{1.0}$ is

[2] The term, intensity, has been frequently misused in the radiological literature to denote the quantity of radiation received by a film during its exposure; consequently many radiologists are unfamiliar with its correct meaning. Stated simply, intensity refers to the brightness of the exposing radiation, or more strictly to the time-rate at which radiant energy is applied to a film.

The relationship between the terms quantity of radiation and intensity of radiation is clearly expressed by the equation, Quantity = Intensity × Exposure Time. Thus, it is evident that, although the two terms are closely related, they must not be used interchangeably.

[3] The terms, quantity of radiation and exposure, have precisely the same meaning.



Figs. 3 and 4. Thermal chamber used in studying the effect of temperature on the brilliance of fluorescent screens. A. Insulating material in upper compartment. B. Turntable on the undersurface of which were mounted samples of the various fluorescent screens, S, which were studied. C. Track carrying standard fluorescent screen, D. E. Lever with which standard fluorescent screen was moved. F. Circulating fan. H. Electric heating element. I. Photoelectric intensitometer, including the phototube, P. L. Lead plate including the aperture, O_2. O_1. Aperture in floor of upper compartment. R. Rotor of turntable, B. T. Thermometers. X. Pathway of x-ray beam (solid line) and pathway of fluorescent light (dotted line).

the exposure required to produce a film-density of 1.0, and d is an arbitrary constant of such magnitude that the various values of s_t fall within a convenient range of numbers.

An analysis of the curves shown in Figure 2 reveals that, when films are exposed at high levels of intensity, an increase in temperature causes an increase in film-speed, whereas at low intensity levels the effect is just the reverse. Between these extremes the effect of temperature may be first in one direction and then in the other.

In view of this complex relationship, it is not surprising that, prior to Webb's observations, the published data on the thermal reaction of photosensitive materials seemed inconsistent. Stumpf (6), in an investigation conducted almost twenty years ago, found that the speed or sensitivity of radiographic films increases and the brilliance of intensifying screens decreases as temperature increases. He concluded that the effects balance one another, and that for all practical purposes films exposed with intensifying screens are unaffected by temperature. In contrast to these observations, Eggert and Luft (3), and Wilsey (7) report that film-sensitivity falls off sharply as temperature rises. From what is now known, it is apparent that Stumpf's observations were conducted at high levels of intensity, whereas those made by Eggert and Luft and by Wilsey were conducted at relatively low intensity levels.

QUANTITATIVE RELATIONSHIP BETWEEN TEMPERATURE AND THE SENSITIVITIES OF RADIOGRAPHIC MATERIALS

During the past few months a comprehensive quantitative study of the influence of temperature on the behavior of radiographic materials has been conducted in this laboratory. The investigation embraced three phases: (1) the examination of various fluorescent screens; (2) the examination of radiographic films exposed with intensifying screens; (3) the examination of radiographic films exposed with x-rays directly.

(1) *Fluorescent Screens:* To study the influence of temperature on the brilliance of fluorescent screens the thermal chamber illustrated in Figures 3 and 4 was constructed. The chamber's upper compartment insulated with Masonite presdwood, included the turntable, B, the electric heating element, H, the circulating fan, F, and the thermometer, T. The compartment was covered by the lead plate, L, having the aperture, O_2, 1.5 inches in diameter. Perpendicularly below O_2, in the floor of the compartment, was another aperture, O_1. The latter opening, sealed with glass to prevent the transmission of heat, permitted light to pass to the lower compartment.

The lower compartment included the radiation detector, I, of a photoelectric intensitometer, the thermometer, T, and the standardizing fluorescent screen, D. The phototube, P, of the intensitometer was located directly beneath the aperture, O_1, and the standardizing screen, D, mounted in the track, C, could be moved over the phototube by means of the lever, E.

Samples, 2 inches square, of the various fluorescent screens to be tested were mounted peripherally on the undersurface of the turntable, B (see Fig. 4). The upper compartment of the thermal chamber was then refrigerated to $-10°$ C., and after establishment of equilibrium temperature conditions an x-ray beam was projected through the chamber along the pathway, X, causing the fluorescent screen below the aperture, O_2, to fluoresce. The intensity of the radiation emitted by the screen was recorded by the intensitometer, I. By rotating the turntable, the remaining screens were brought into the x-ray beam and their brilliance was measured. The procedure was repeated at temperatures ranging to 60° C., the heating element, H, providing the desired rise in temperature. From time to time during the investigation readings of the emission of the standardizing fluorescent screen, D, were made. It was thus possible to maintain the intensity of the x-ray beam constant while the study was in progress.

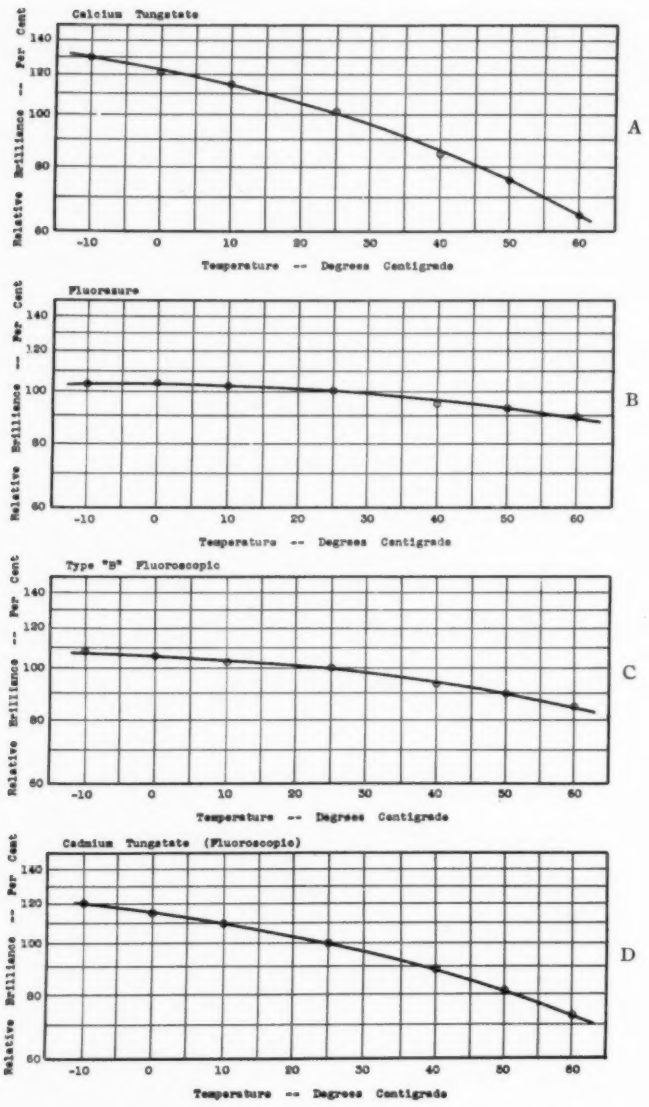


Fig. 5. Relative brilliance of various fluorescent screens through a range of temperature extending from −10 to 60° C. A. Calcium tungstate intensifying screens. B. Fluorazure and photoroentgen screens. C. Type "B" fluoroscopic screen. D. Cadmium tungstate (fluoroscopic) screen.

Type "B" fluoroscopic, fluorazure, photoroentgen, cadmium tungstate (fluoroscopic), and nine brands of calcium tungstate intensifying screens were examined. The results of the study are illustrated in Figure 5, where the relative brilliance of the several materials is plotted through a range of temperature extending from −10° C. to 60° C. In each case the temperature of 25° C. indicates a relative brilliance of 100 per cent. The nine brands of calcium tungstate intensifying screens behaved al-

most identically and for practical purposes can be represented by the single curve shown in Figure 5A. It will be observed that at 0° C. these screens have a brilliance approximately 25 per cent greater than that occurring at room-temperature, whereas at 50° C. their brilliance is approximately 25 per cent less. The characteristics of fluorazure and photo-roentgen screens are shown in Figure 5B. As previously mentioned, these materials exhibit relatively little change in brilliance as temperature is varied from −10° C. to 60° C. The same is also true of the type "B" fluoroscopic screen (Fig. 5C). Figure 5D illustrates the characteristics of the now obsolete cadmium tungstate (fluoroscopic) screen. It will be observed that these are similar to those of calcium tungstate intensifying screens.

(2) *Radiographic Films Exposed with Intensifying Screens:* The thermal chamber illustrated in Figures 3 and 4 was also used to study the influence of temperature on the sensitivity of radiographic films exposed with intensifying screens, the turntable, *B*, being replaced by a cassette which included a pair of calcium tungstate intensifying screens and strips of the various films to be tested. The sensitometric procedure which was followed was the aluminum-ladder method of White (8) and was conducted at temperatures ranging from −5° C. to 55° C., and at intensity levels ranging from that which produced a film-density of approximately 2.0 at an exposure time of 1/120 of a second to that which produced a similar degree of blackening at an exposure time of 1,000 seconds. The radiation with which the various exposures were made was provided by a full-wave valve-rectified machine, and the exposures received by the films were recorded by a photoelectric roentgen-ray intensitometer (9) operating as an integrating device and having a quality response identical to that of the various film-screen combinations. The intensity of the exposing radiation was varied by changing the target-film distance, the voltage of the roentgen tube, and by placing aluminum filtration in the roentgen beam. In no exposure, however, did the half-value layer of the radiation vary more than 10 per cent from a value of 1.0 mm. of aluminum. It was considered desirable to maintain the quality of the radiation constant within these limits in order that the contribution to film-blackening by the front and back intensifying screens be uniform throughout the investigation. Thus the sensitometric data were not influenced by the quality of the exposing radiation.

Four commercial brands of radiographic film were examined. The results of the investigation are illustrated graphically in Figure 6, where the exposures required to produce a film-density of 1.0 are plotted through a wide range of intensity at three levels of temperature. As in Figures 1 and 2, the diagonals indicate the exposure times which correspond to the various intensity levels. The abscissae refer to the intensity of the radiation emitted by the fluorescent intensifying screens rather than that of the x-radiation. Thus Figure 6 indicates the effect of temperature on the behavior of the films themselves and not on the behavior of the film-screen combinations.

Figure 7 illustrates the relative speeds of the four brands of film plotted through a range of temperature extending from −5° C. to 55° C. at three intensity levels. These data were calculated from Figure 6 by means of equation (1).

The range of intensity employed in general radiography corresponds to that extending from a relative intensity of 0.1 to a relative intensity of 10 (Figs. 6 and 7). The intensity at which lateral lumbar spines are filmed is of the order of 0.1; that is, the intensity of the radiation reaching the film under these circumstances is usually low. The intensity of the radiation at which chest examinations are usually performed corresponds to a relative intensity of approximately 10. Other radiographic procedures fall between these two limits in most cases.

It will be observed that, at intensity levels at which chest examinations are conducted (curve 3, Fig. 7), the effect of

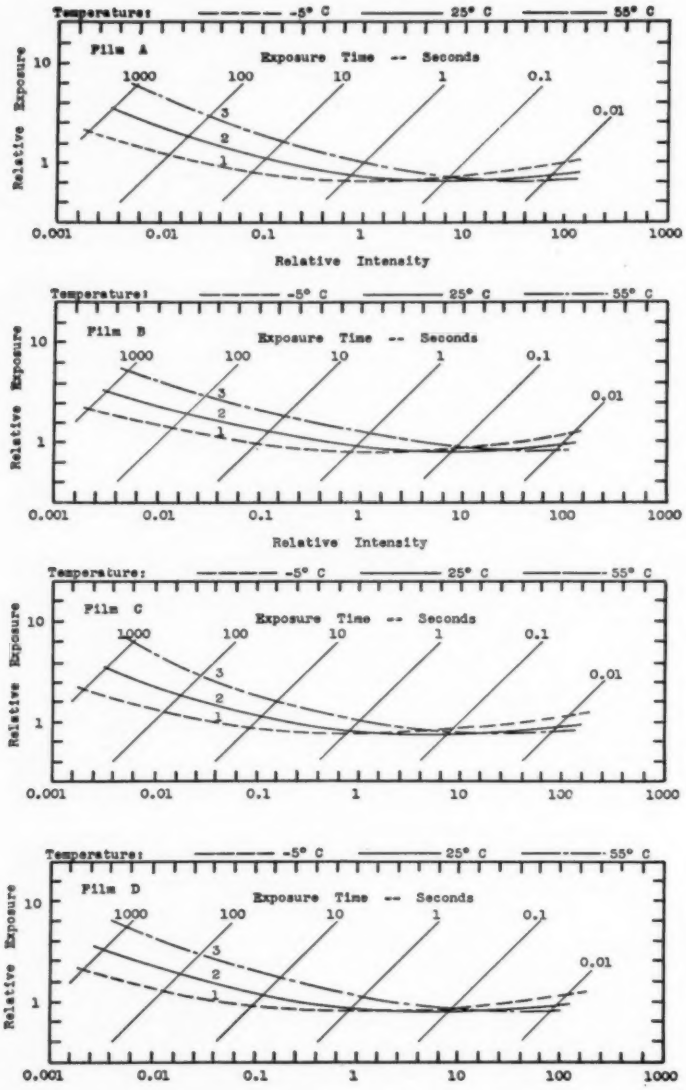


Fig. 6. Relative exposures required to produce a density of 1.0 in four commercial brands of radiographic film exposed with light (from calcium tungstate intensifying screens) at various levels of intensity. Curve 1. −5° C. Curve 2. 25° C. Curve 3. 55° C.

temperature on film speed is small. At intensity levels corresponding to those at which lateral lumbar spine filming is conducted, however (curve 1, Fig. 7), the effect of temperature is relatively great; indeed, some films exhibit a 65 per cent drop in sensitivity as temperature rises from −10° C. to 60° C. The effect of temperature on film-speed at intensity levels corresponding to those at which the bulk of radiographic examinations (relative intensity of 1.0) are conducted is somewhat less than that at the very low intensity levels.

The combined effects of temperature on the brilliance of calcium tungstate intensi-

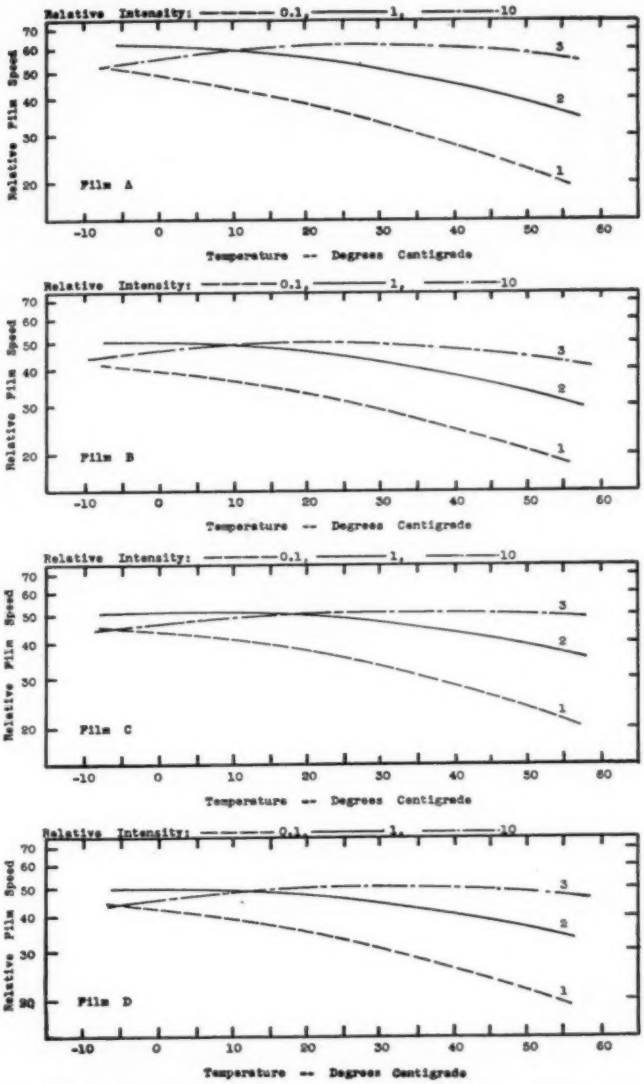


Fig. 7. Effect of temperature on the relative speeds of four commercial brands of radiographic film exposed with light (from calcium tungstate intensifying screens). Curve 1. Exposures made at relative intensity of 0.1 (conditions encountered when filming lateral lumbar spine). Curve 2. Exposures made at relative intensity of 1.0 (most radiographic procedures are conducted at or near this intensity level). Curve 3. Exposures made at relative intensity of 10 (radiography of the chest is conducted at or near this intensity level).

fying screens and on the speed of radiographic film are shown in Figure 8. Here are plotted the relative exposures required to produce a film-density of 1.0 (average density of a correctly exposed roentgenogram) in each of the four brands of film whose characteristics are shown in Figures 6 and 7, when exposed with calcium tungstate intensifying screens at temperatures ranging from −10° C. to 60° C. As before, curves 1, 2, and 3 indicate the required exposures when the intensity levels

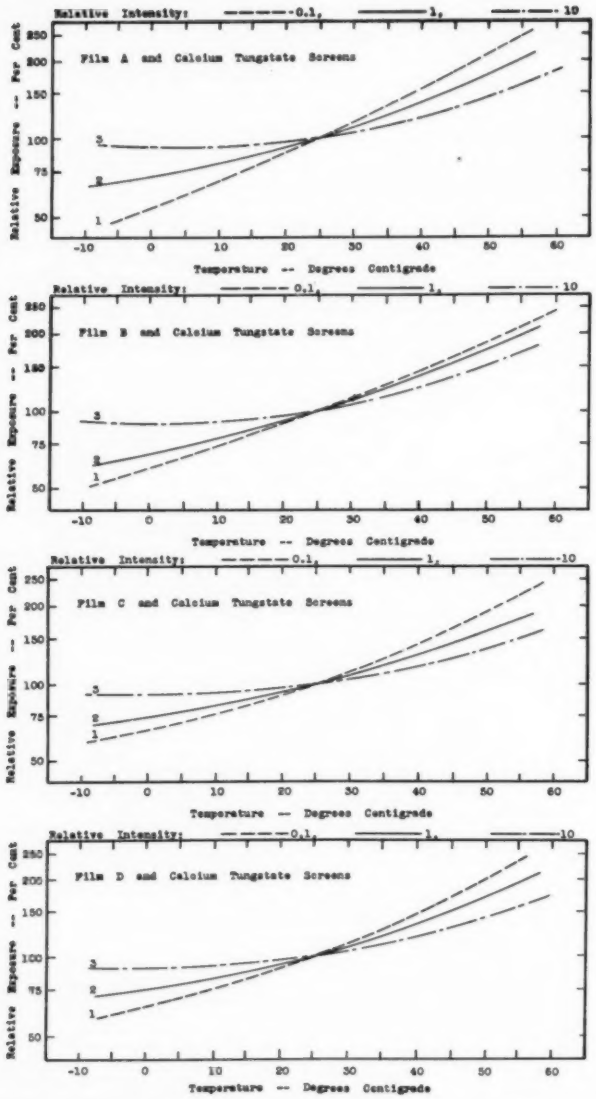


Fig. 8. Relative exposures required to produce correctly exposed roentgenograms at various temperature levels compared to that required at 25° C. Curve 1. Exposures made at relative intensity of 0.1 (lateral lumbar spine filming). Curve 2. Exposures made at relative intensity of 1.0 (most radiographic examinations are conducted at or near this intensity level). Curve 3. Exposures made at relative intensity of 10 (chest radiography). These curves apply only to films exposed with calcium tungstate intensifying screens.

are 0.1, 1.0 and 10, respectively. Each curve has been plotted on the basis that 100 per cent exposure is required at a temperature of 25° C. These curves, therefore, do not provide a means for comparing the relative sensitivities of the various film-screen combinations, nor the relative sensitivities of a single combination at various intensity levels. Such data can be calculated from Figures 5 and 7. In most

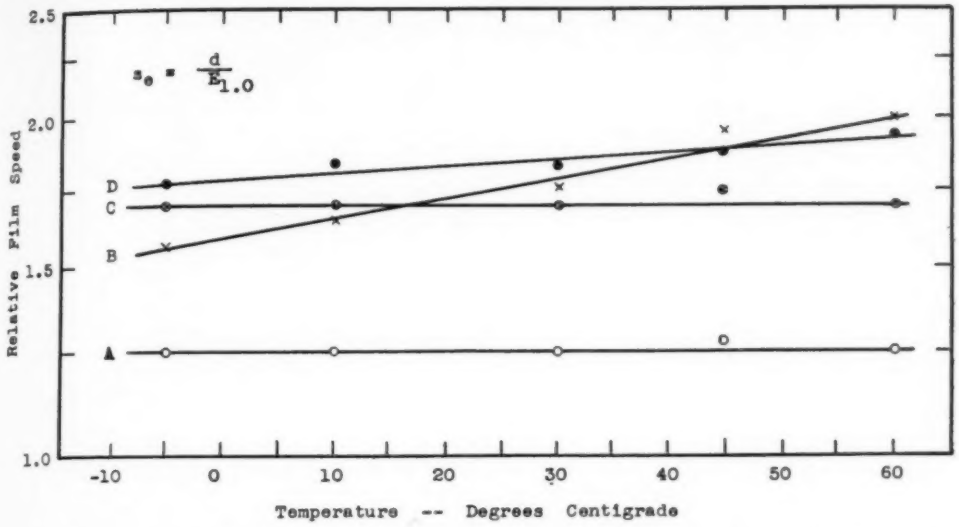


Fig. 9. Effect of temperature on the relative film-speeds of four commercial brands of radiographic film exposed with x-rays directly.

cases, however, the radiologist who is seeking information regarding the effect of temperature on the speed of a radiographic film is interested only in knowing the amount of exposure which is necessary at the temperature at which he is working relative to that which is required under normal operating conditions (*e.g.*, room-temperatures). The curves in Figure 8 provide such information.

At the levels of intensity used in chest radiography (curve 3) the effect of temperature on the sensitivities of the various film-screen combinations is negligible below 25° C. Above room-temperature, the amount of radiation required to produce a given radiographic effect rises slowly until at 60° C. the necessary exposure is between 50 and 100 per cent greater than that at room-temperature. At intensity levels corresponding to those at which the bulk of radiographic examinations are conducted, the effect of temperature on the speed of the film-screen combinations is such that almost three times as much radiation is required at 60° C. as at −10° C. At low levels of intensity (conditions at which lateral lumbar spine films are made), the effect of temperature is even more marked. Here approximately five times as much radiation is necessary to produce a particular radiographic effect at 60° C. as at −10° C.

Within the usual range of room-temperature (20 to 35° C.), radiographic films exposed with intensifying screens exhibit little change in sensitivity under most circumstances. When the intensity of the radiation falling on the radiographic film is low, requiring exposure times in excess of five seconds, however, almost 70 per cent more radiation is required at 35° C. than at 20° C. Thus the effect of temperature becomes important when raying heavy structures or when using low-powered radiographic equipment.

From the standpoint of photoroentgenography, it is interesting to observe that the effect of temperature on fluorazure, photoroentgen, and type "B" fluoroscopic screens (Fig. 5) is small. Since the same is also true of radiographic film exposed at high intensity levels there is, therefore, no significant over-all change in the sensitivity of photoroentgenographic and photofluorographic materials through a range of temperature extending from −10° C. to 60° C.

(3) *Radiographic Films Exposed with X-rays Directly:* The speeds of four brands of radiographic films exposed with x-rays directly were also examined. Since films exposed in this manner do not exhibit reciprocity law failure (5), it was not necessary to conduct the examination at several levels of intensity. The results of the investigation are illustrated in Figure 9. In general, the effect of temperature on films exposed in this manner is small. Indeed, no change in sensitivity was detected in films A and C over the temperature range of $-5°$ C. to $55°$ C. Films B and D, however, exhibited a small rise in sensitivity over this range of temperature.

SUMMARY

Quantitative data on the relationship between temperature and the brilliance of fluorescent screens and the sensitivities or speeds of radiographic films exposed both with and without intensifying screens have been presented. Within the usual range of room-temperature the sensitivities of various radiographic materials available today are relatively constant, except under conditions where long exposure times are employed (lateral lumbar spine technic). Over greater ranges of temperature, such as those which may be encountered in the military services, changes in the sensitivities of x-ray films and screens are frequently large. The effect of temperature on the speed or sensitivity of radiographic films exposed with x-rays directly is negligible through a long range of temperature.

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The Roentgen Diagnosis of Hypertrophic Pyloric Stenosis in Infants[1]

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HYPERTROPHIC pyloric stenosis in infants is a fairly common disease, the recognition of which is usually quite reliable and simple by means of the history and clinical signs. The first symptom of the disease, usually noticed about two to three weeks after birth, is vomiting which soon becomes projectile and is most noticeable immediately after meals. Gastric peristalsis can be seen in the greater number of cases and the hypertrophied muscle is palpable in many instances. Rapid inanition and extreme emaciation take place in many infants and, along with these, severe constipation. Male infants are predominantly affected, the ratio between male and female being 4:1.

Pathologically a tumor is found in the prepyloric region, as hard as cartilage and usually 2 to 3 cm. long and 1 to 1.5 cm. thick. It corresponds to the prepyloric portion of the stomach directly adjoining the pylorus. Its borders are sharply defined. Microscopically it is described as hypertrophy of the muscularis mucosae with some hypertrophy of the connective tissue and some engorgement of the vessels.

The etiology is undetermined. Some investigators believe that the hypertrophy is secondary to a spasm; others maintain that it is primary. There is at times a familial tendency to the disease.

Other conditions may simulate pyloric stenosis, especially the gastric symptoms of a spastic infant, but also obstructions lower in the intestinal tract and at times even diseases of other organs which produce vomiting of extended duration. The only truly reliable diagnostic sign for the clinician is the palpation of the prepyloric tumor. This is possible in a large percentage of cases. The figure varies as given in the literature: Rinvik, 72 per cent; Seeger, "usually palpable . . . with care"; Tallermann, 94 per cent; Brown, 50 per cent, with 10 per cent questionable; Donovan, 100 per cent; Parmelee, "usually; now and then not possible."

At the Milwaukee Children's Hospital and the Milwaukee Hospital the pediatricians and surgeons are divided in their opinions about reliable palpation of the tumor; some believe it possible to feel the tumor in most cases while others think it is palpable in less than 50 per cent. It has been noted that on some occasions when a tumor was believed to have been felt it was not found at operation.

One may say that the clinical diagnosis is usually reliable, but that in a certain percentage of cases—not too small—the clinical picture may lead to a wrong diagnosis.

The roentgen diagnosis of pyloric stenosis has been used to supplement the clinical diagnosis. The first report on x-ray examination for this disease was made by Kerley and LeWald in 1923. Only the emptying rate of the stomach was considered, and the method did not become widely used.

The first description of a direct demonstration of the narrowed prepyloric canal was given by Meuwissen and Sloof (1932). They reiterated that the stomach has no definite shape or position in an infant and pointed out that emptying begins immediately after taking food or barium and is usually complete in from two to five hours. X-ray signs, as hyperperistalsis and a thickened wall of the stomach, are unreliable evidence in their opinion, as are antiperistalsis and dilatation of the stom-

[1] From the Radiological Departments of the Milwaukee Children's Hospital and Milwaukee Hospital, Milwaukee, Wis. Read by title at the Twenty-ninth Annual Meeting of the Radiological Society of North America, Chicago, Ill., Dec. 1–2, 1943.

ach. They found the technic of the x-ray examination unreliable and were able to demonstrate, by fluoroscopy and films, the actual anatomical appearance of the pyloric stenosis, that is, the narrowed prepyloric canal, which is the first and by far the most important x-ray sign of the disease. It is necessary, according to these writers, to obtain films in the right oblique position, since on an anteroposterior film the pylorus and duodenal cap are often not seen because of their anatomical position posterior to the prepyloric region.

Fig. 1. Normal stomach and pylorus with normal pyloric opening time, seen on right oblique film.

The contention of Meuwissen and Sloof that it is always possible with the correct technic to demonstrate the narrowed prepyloric canal was upheld by many Scandinavian clinicians and roentgenologists (Rinvik, Andresen, Runström, Salmi, Frimann-Dahl). Very little mention is made in American literature of this radiological sign. Some authors believe that x-ray examination is not helpful and not necessary (Knox, Brown, Donovan, Ladd); others attribute some value to it in doubtful cases. The roentgen-anatomical visualization of the narrowed pyloric canal is mentioned by Rigler as being occasionally obtained.

During the last three years many cases of pyloric stenosis have been examined roentgenologically at the Milwaukee Children's Hospital and the Milwakee Hospital, most of them clinically diagnosed, some of them clinically questionable. Of more than 150 infants examined because of the question of pyloric stenosis, 68 were operated on with the x-ray diagnosis of pyloric stenosis. In all of these the tumor was found and a Ramstedt operation was done. In 3 cases the clinical diagnosis of pyloric stenosis could not be substantiated by radiological examination, and in these no tumor was found at operation. In the other 38 cases where there was a clinical question of a pyloric stenosis, the roentgen examination showed a normal stomach and pylorus, which was proved correct by the later clinical course. Before undertaking this study, 20 normal infants were examined to establish normal findings in infants of between two and four weeks.

One of the most important facts in the correct diagnosis of pyloric stenosis is a knowledge of technical features. Because of the posterior position and angulation of the pylorus and duodenal cap in many infants, often far posterior under the liver, the routine anteroposterior or postero-anterior films of the stomach are, when taken solely, of very limited value or none at all. One may determine the shape and size of the stomach by these views, but they are of relatively no importance. The size of an infant's stomach depends upon its state of filling, be it with food, secretion, or air. The largest stomachs are seen when infants have swallowed a great amount of air. The same stomachs seen on another occasion may be of different size and entirely normal. Nor is the shape of the stomach of any practical importance so far as the x-ray examination is concerned. As many as 12 shapes have been described (Willi), dependent mainly on the food and air content, the filling of the colon with feces and air, and constitutional factors.

Peristaltic waves are normally seen in an infant's stomach, but when the stomach is

overextended by air they may be temporarily absent. Antiperistalsis might be noted before and after vomiting of any etiology.

The pylorus and duodenal cap are, as expected, very small and can be seen only seldom on routine postero-anterior views. It is possible practically always to see them in right oblique and right lateral views (Fig. 1). The best position for their demonstration on films can be determined by fluoroscopy. At times it is necessary to use right oblique films with different rotation of the infant to get the correct visualization. At other times the straight right lateral view will demonstrate the pylorus and duodenal cap when all other views fail.

The pyloric opening time is of considerable importance for x-ray examination. A normal pylorus in an infant will open and discharge barium into the duodenum practically always during feeding. When 2 ounces of a mixture of barium and feeding formula are given, barium is seen to have passed the pylorus in less than five minutes after the feeding is finished. A prerequisite is, of course, an empty stomach, usually obtained by withholding food and water for six hours, rarely by gastric lavage.

If the pyloric opening time is delayed longer than five minutes, the presumptive diagnosis of pyloric stenosis becomes very likely. In most cases of pyloric stenosis the opening time is found to be between fifteen and sixty minutes. In very early cases (4 in this series) it is occasionally normal; in very advanced cases it may be delayed up to three hours, with no barium seen in the duodenum or small intestines at that time (Table I).

TABLE I: PYLORIC OPENING TIME IN PYLORIC STENOSIS, AS CHARTED FROM 68 CASES

(Normal pyloric opening time up to five minutes after feeding)

Normal (5 minutes)	4
Between 5 and 15 minutes	20
Between 15 and 60 minutes	26
Over 1 hour	18
TOTAL	68

The emptying time of the stomach in infants two to four weeks old is normally between two and four hours when 2 ounces of a barium mixture are given. At times a little barium is seen in the stomach after a longer interval. It is of considerably less importance in the diagnosis of pyloric stenosis than it is given credit for in the literature. Of course, when no barium at all has left the stomach in two or three hours, the diagnosis of pyloric stenosis is most likely, that representing a marked delay in the pyloric opening time. In many cases of proved disease with large tumors the

Fig. 2. Postero-anterior film of stomach. Pylorus not visible.

opening time of the pylorus was considerably delayed, up to one hour, and yet the emptying time of the stomach was entirely normal; that is, in three to four hours no barium remained in the stomach. Usually, but not always, the severity and duration of the disease correspond with the delay in the gastric emptying time.

In a few cases it was thought that a thickened gastric wall could be seen on edge when the stomach was filled with enough air to demonstrate it. This sign, however, was of no help.

The sign which is always present and the only entirely reliable roentgen finding is the narrowed prepyloric canal. It is seen as a persistent narrowing of the prepylorus, 1.5 to 2.5 cm. long, corresponding anatomically to the narrowed lumen surrounded by the hypertrophied muscle.

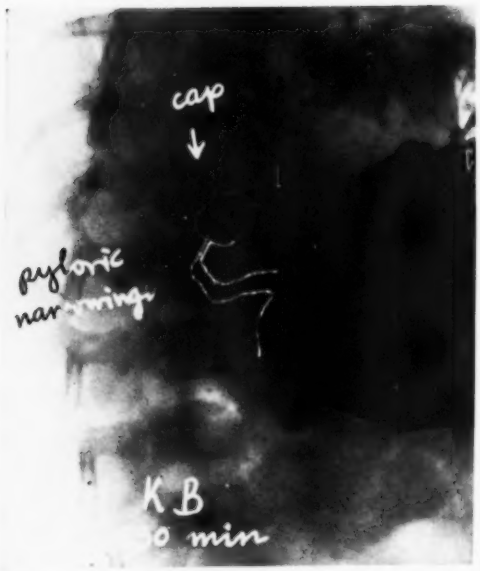

Fig. 3. Right oblique film of stomach with typical prepyloric narrowing and delayed pyloric opening time (30 minutes).

Occasionally one may see it on the postero-anterior film, but in most cases it is hidden by the barium in the more proximal parts of the stomach (Fig. 2). At times it is easily seen fluoroscopically; at other times the fine streak of barium is so narrow that it cannot be made out by the fluoroscopic examination (about 50 per cent of the cases). It is then necessary to determine during fluoroscopy the best position for a film. Not always do the first two or three films show the narrowed canal. At least a minimal amount of barium must have left the stomach for demonstration of the pylorus and duodenal cap. If the pylorus does not open during the time of fluoroscopy and the first set of films, another series of films is taken in thirty minutes and still another one hour afterward (Figs. 3–5). In practically all cases the pylorus and at least part of the duodenal cap can be seen on at least one, usually more than one, film. If there is still a question, a re-examination is done the next day, but this was necessary in only 2 of our 68 cases.

If a normal opening time of the pylorus and a normal size, length, and width of the pylorus and prepyloric region are demonstrable by fluoroscopy, done 5 minutes after the feeding is finished, and in the first films, no further films are considered necessary, as the emptying time in such cases is of no interest, except for the rare occurrence of duodenal obstruction which may

Fig. 4. Right oblique film of stomach with typical prepyloric narrowing.

be picked out by that time and by clinical impression (the vomitus contains bile in such cases).

Of interest is the observation of the stomach after the Ramstedt operation has been done. Usually the pyloric opening time becomes normal within a short time. The deformity of the pylorus with its narrowing is still demonstrable for a considerable time. According to some Scandinavian authors, narrowing has persisted in some patients up to puberty.

Of importance also is the observation of the esophagus, which, rarely, shows some dilatation and even spasm at the cardiac

Fig. 5. Postero-anterior film showing a typical prepyloric narrowing and a delayed pyloric opening time.

end. In one case an untreatable obstruction developed at the cardia, of immense mucosal folds, leading to a complete obstruction and the death of the infant, after the pyloric stenosis was relieved by surgery.

CONCLUSIONS

(1) Roentgen examination of the stomach in cases of pyloric stenosis allows a correct diagnosis in practically all cases and is often of help to the pediatrician and surgeon.

(2) The pyloric opening time is of much value in diagnosis, while the emptying time of the stomach is of relatively little assistance.

(3) The most important x-ray sign is the actual demonstration of the narrowed prepyloric canal by fluoroscopy and, more important, by films.

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Castration for Advanced Malignant Growth: Short Historical Review with a Case Report[1]

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THERE HAS occurred a tremendous resurgence of experimentation to determine the effects of castration on malignant growth, particularly following the publication by Huggins (1) and his associates of their study of orchiectomy in advanced carcinoma of the prostate. This widespread interest is illustrated by the following statement in the Memorial Hospital Triennial Report (2): "The first and most important is the work of Doctor Farrow on the value of orchidectomy in the cases of advanced carcinoma in the male breast," and by numerous publications dealing with orchiectomy for prostatic carcinoma. That such a procedure has not the curative effects hoped for in the first flush of activity is suggested by the recent report of Kretschmer (3).

The first favorable report on the effects of castration in cancer was published over half a century ago (1889) by Schinzinger (4), who described improvement following oophorectomy in mammary carcinoma. This was independently attested to by Beatson (5), who in 1896 described shrinking of the primary breast tumor and its metastases. Dresser (6) more recently reported on improvement in metastases secondary to breast carcinoma following x-ray castration in young women.

It was only logical, then, that experiments be made to determine the value of castration in other neoplastic conditions than those primary in the breast and prostate. Among the studies reported were those of Herbst (7), who obtained temporary improvement in a case of malignant melanoma of the choroid with metastases following orchiectomy.

The following clues have been listed (Howes, 8) which would tend to link melanoma with the sex glands:

Fig. 1. Melanoma arising from conjunctiva of left eye.

"(1) With adolescence there is a localized deposition of pigment in the skin of the genitalia and about the areola of the breasts.

"(2) Pigmented nevi which remain quiescent in infancy and childhood have been known to become activated during adolescence or later in (adult) life. The only reported case of a baby dying of malignant melanoma is that of Parkes Weber (9), who described a case of melanoma transmitted from mother to child *via* the placenta, with death of both."

The following case is presented to illustrate that in our limited experience orchiectomy has had no effect in retarding the growth or diminishing the symptoms of malignant melanoma arising in the conjunctiva.

CASE REPORT

E. W., 47-year-old white male, reported to the Out-Patient Department of the Brooklyn Cancer Institute in January 1942. He had known of the

[1] Accepted for publication in December 1943.

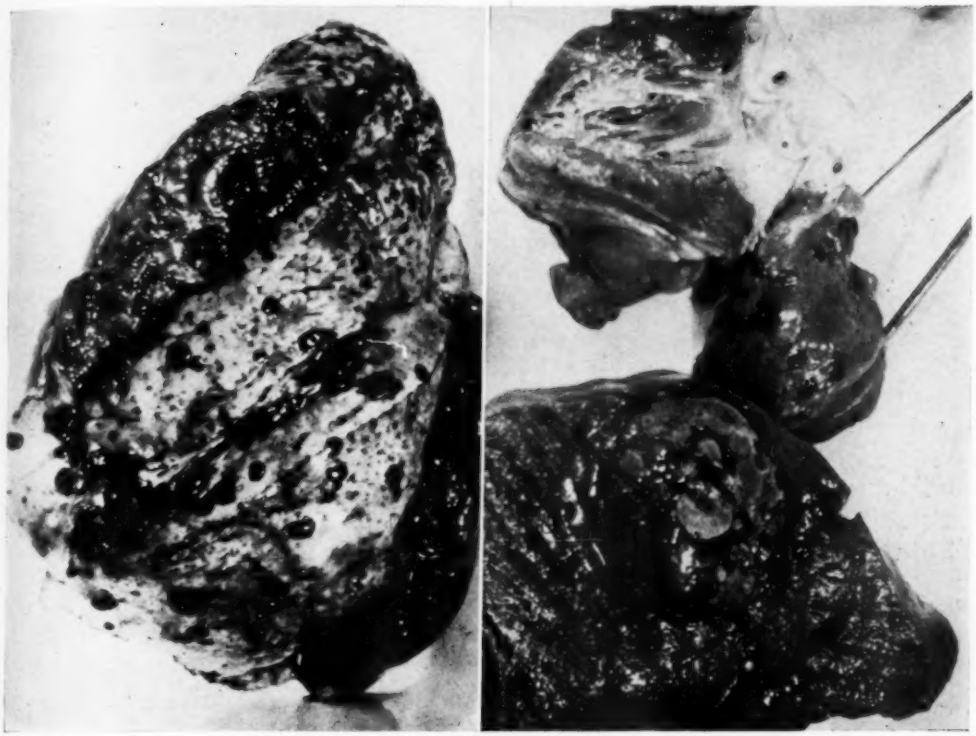

Fig. 2. Metastases in pleura and in myocardium, pericardium, and lung.

presence of a small black spot on the inner surface of his left eye for the past eight years. This had suddenly started growing about one year previously, forming a coal-black fleshy mass filling the inner angle of the eye. There was no pain and no interference with vision. Medical advice was sought merely because the mass was growing and because of its unsightliness.

On examination, a deeply pigmented papilloma measuring 0.25 × 1.0 × 1.0 cm. was seen arising from the conjunctival surface of the left lower lid, with ulceration along the sulcus between the lower eyelid and the orbital conjunctiva. The patient was otherwise healthy, without evidence of metastasis. His liver was not enlarged.

A radical exenteration of the orbit was determined upon as the procedure of choice. This was done in another hospital on Jan. 31, 1942. The pathologist reported the growth as "melanoma of caruncle and conjunctiva, left." Within one month, the skin grafts had taken and the patient was discharged with a favorable prognosis. He remained well, without visible recurrence or metastasis, for about one year.

In February 1943, or approximately one year following the exenteration, a subcutaneous button-like growth was palpated on the anterior abdominal wall. A biopsy excision proved this to be "melanoma, metastatic." Soon thereafter, bluish-black nodules developed on the roof of the exenterated orbit and innumerable skin metastases appeared, mostly over the trunk. The liver rapidly enlarged, and ascites became evident. About this time the staff of the Brooklyn Cancer Institute determined on an orchiectomy with the hope that the removal of the testicular hormone might impede the growth and spread of these metastatic lesions.

On April 26, orchiectomy was done. There was no operative reaction. The patient, however, continued his downhill course and died on June 24, 1943, without any clinical evidence that the orchiectomy had in any way changed the course of the disease.

Autopsy was done. The following is a summary of the anatomicopathologic diagnosis: Melanoma arising in conjunctiva of left eye (exenteration left orbit); metastasis to the orbital roof; metastasis to skin, both lungs, hilar nodes, pleurae; pleural effusion, right; metastases to pericardium and myocardium; metastases to spleen, liver, kidney. mesentery, peritoneum, omentum; ascites. There was nothing in the gross or microscopic findings

Fig. 3. Metastases in omentum.

to suggest that the orchiectomy had in any way affected the pathological picture.

COMMENT

Caution is suggested before castration is carried out in cases of malignant growth other than those with the primary lesion in the breast or prostate.

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Leukemia in Radiologists[1]

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FOR MANY YEARS there has been prevalent an impression of a possible relationship between exposure to radiation and the subsequent development of leukemia. As early as 1911 there appeared the first report on the matter by von Jagic and coworkers (1), in which a brief statement—based in part on hearsay—is made concerning the occurrence of leukemia in four persons who had experienced prolonged exposure to radiation. Of only one of these cases did the authors have any personal knowledge. Since that time there have appeared perhaps a dozen reports on the specific subject of the development of leukemia in persons non-therapeutically exposed to small doses of radiation over prolonged periods. Twenty-three cases have been recorded in the literature, including the four by von Jagic. In a few of the cases details are lacking and the relationship is not well established.

In 1912 Aubertin (2) referred to a case of myeloid leukemia discovered in a French radiologist and followed by Vaquez. In 1924 Carman and Miller (3) reported a case of lymphatic leukemia in an American roentgenologist. The following year Emile-Weil and Lacassagne (4) published a report of myeloid leukemia in a research worker in radioactive bodies and recalled that Béclère had observed a similar case in a radiologist. In 1927 Davey and Whitby (5) added a case of acute leukemia in a "medical man who had worked with x-rays for many years," and in 1928 Evans and Roberts (6) reported a case of myeloid leukemia occurring in an x-ray worker, at the same time reviewing the ten cases that had been recorded up to that time. They concluded that the case against radiations as a cause of leukemia was not yet proved, since actually only the two cases of Carman and Miller and Emile-Weil and Lacassagne occurred in persons who were known from definite first-hand information to have experienced prolonged exposures to small amounts of radiation.

Aubertin (7), in 1931, stated that over a period of nineteen years he had the opportunity of seeing five radiologists afflicted with myeloid leukemia, while during the same space of time he had observed only one case in a physician other than a radiologist. Since the radiologists constitute only a small proportion of the medical profession, he concluded, on the basis of his personal experience, that myeloid leukemia is undoubtedly more frequent in radiologists than in other doctors. In the same year Haagensen (8), at the Memorial Hospital, New York, cited a case of leukemia developing in a person exposed to radiation over a prolonged period. The following year a case was added by Nielsen (10) and another by Laubry and Marchal (9). The latter writers quote a case of Znajewska. In 1937 Emile-Weil (11) reported a case of aleukemic lymphatic leukemia in a radiologist and stated: "There have been published more and more cases of leukemia, lymphatic as well as myelogenous, in radiologists, the disorder being an occupational one with them." Weitz (12) in 1938 and Maingot and his co-workers (13) in the same year each added a case. The latter writers quote Lavedan as also having seen a case.

During the year 1943 the writer was impressed by the death of three radiologists from leukemia. It was thought worth while, therefore, to see whether over a period of years there had occurred a higher incidence of the disease among radiologists than among non-radiological physicians. No such statistical study appears ever to have been made; only a vague impression that this greater incidence exists seems to be prevalent as a result of the reports cited

[1] Accepted for publication in June 1944.

above. On the other hand, some persons are not at all convinced that any causal relationship has ever been demonstrated.

The incidence of leukemia in physicians is easily determined through a study of the death notices appearing in the *Journal of the American Medical Association*, since leukemia is a fatal disease. Unfortunately, the cause of death is not given for every physician, but eventually the files of the Association become fairly complete, so that by the time the annual editorial on deaths among the medical profession is written, only 2 or 3 per cent of the deaths recorded remain listed without cause, and this very small proportion is negligible. The total number of deaths listed was therefore used to compute the percentages.

While the present paper was in preparation, there appeared an article by Henshaw and Hawkins (18) in which they reported for a ten-year period an incidence of 0.53 per cent of leukemia among physicians for whom the cause of death was given (26,788). This includes all physicians, radiologists and non-radiologists. The number of cases of leukemia listed by Henshaw and Hawkins is lower than the official figures listed annually by the American Medical Association in its editorial on physicians' deaths. According to the latter, over the fifteen-year period from 1929 to 1943, inclusive, notices of the deaths of 50,342 physicians appeared in the *Journal of the American Medical Association;* 229 deaths were reported as due to leukemia, giving an over-all incidence for physicians of 0.45 per cent.

There is no single agency on file that records deaths of radiologists. For the purposes of this paper, a review was made of all of the death notices that have appeared in RADIOLOGY and in the *American Journal of Roentgenology and Radium Therapy* during the fifteen-year period under consideration. Honorary members, foreign members, and laymen whose obituaries were published were omitted from consideration, since they were not pertinent for comparative purposes. Care was exercised to avoid duplication. A complete list of members of the American Roentgen Ray Society and of the American College of Radiology who had died was obtained, and the deaths not recorded in the above journals were then traced through notices appearing in the *Journal of the American Medical Association*. Lists of deceased members could not be obtained from the other national radiological societies. From the sources stated, however, the writer believes that a representative and nearly complete list of deceased radiologists has been obtained for the latter years of this decade and a half; in the earlier years the total number of radiologists was fewer, and the deaths of only the most distinguished were recorded in the radiological journals. Records of the deaths of a total of 175 radiologists were found during this fifteen-year period. The annual distribution of these deaths is given in Table I.

TABLE I: DEATHS OF RADIOLOGISTS, 1929–1943

1943	20	1935	8
1942	27	1934	5
1941	17	1933	11
1940	19	1932	7
1939	21	1931	7
1938	8	1930	6
1937	13	1929	1
1936	5	Total	175

Of these 175 deaths, the cause is recorded in 173. In spite of the fact that in 2 instances no cause of death is recorded, it does not seem unreasonable to assume that neither was due to leukemia, since a leukemia death would probably have been mentioned because of the possible occupational relationship. At any rate, one is erring only on the side of conservatism in such an assumption. Moreover, the percentage unreported in the radiological group approximates the percentage unreported in the larger group of physicians as a whole. During this period 8 radiologists are known to have died of leukemia, and these 8 cases are listed in Table II. This gives an incidence of all types of leukemia in radiologists of 4.57 per cent, based on deaths during the past fifteen years.

In order properly to evaluate this figure, it would be necessary to compare it with the incidence of leukemia in physicians

TABLE II: DEATHS FROM LEUKEMIA IN RADIOLOGISTS, 1929–1943

Initials	Date of Death	Type of Leukemia Recorded	Age	Location
W. C.	Oct. 17, 1943	Lymphatic	54	Petersburg, Va.
I. G. F.	July 15, 1943	Acute	43	Harlingen, Tex.
C. G. D.	April 23, 1943	Acute myelogenous	42	New York, N. Y.
J. J. L.	Feb. 22, 1942	Acute myelogenous	63	Syracuse, N. Y.
W. W. F.	July 10, 1940	Leukemia	48	Rochester, Minn.
L. J.	Jan. 23, 1939	Chronic lymphatic	65	New York, N. Y.
L. I. L.	June 24, 1938	Leukemia	52	Buffalo, N. Y.
J. F. H.	Feb. 23, 1933	Lymphatic	69	Ottumwa, Iowa

who are not radiologists, for one can assume that the latter group as a whole does not receive any appreciable amount of irradiation, even though a small percentage do use fluoroscopes. There have thus been 50,160 deaths among non-radiological physicians and 221 cases of leukemia, an incidence of 0.44 per cent. The incidence of leukemia in radiologists has thus been more than ten times as great as its incidence in physicians who are not radiologists.

Because of the relatively small size of the group of radiologists, *i.e.*, the sampling, it is necessary to apply some statistical test of significance to the results. There are several avenues of approach. The usual test (15) concerns the use of the probable error of the difference in the two rates of incidence under consideration, employing the formula $P.E. = \frac{0.67449}{\sqrt{n}}\sqrt{pq}$, where *P.E.* is the probable error of the rate of incidence, n the total number of observations, p the proportion of positive cases, and q the proportion of "negative" cases or escapes. Thus, the probable error in the incidence of leukemia in non-radiological physicians is

$$P.E. = \frac{0.67449}{\sqrt{50{,}160}}\sqrt{0.00441 \times 0.99559} = \pm 0.0002$$

The probable error for the incidence of leukemia in radiologists is

$$P.E. = \frac{0.67449}{\sqrt{175}}\sqrt{0.04571 \times 0.95429} = \pm 0.0106$$

Now, the probable error of a difference between any two independent quantities is equal to the square root of the sums of the squares of their respective probable errors. Thus

$$P.E._{a-b} = \sqrt{P.E._a^2 + P.E._b^2}$$

where a and b are the independent quantities.

The difference in the matter under consideration is between the percentage incidence of leukemia in radiologists (4.57 per cent) and non-radiologists (0.44 per cent) as given above. Therefore

$$0.04571\ (\pm 0.0106) - 0.00441\ (\pm 0.0002) = 0.0413 \pm 0.0106$$

since

$$\sqrt{(0.0106)^2 + (0.0002)^2} = 0.0106$$

The difference (0.00413) is 3.9 times as large as its probable error (0.0106), which difference is ordinarily considered as significant.

Because the normal curve is a very poor approximation (17) when the expected number of cases is less than 5 (and in our case it would be 0.8 case at the rate of 0.441 per cent), it is better to determine the probability by the appropriate term in the expansion of the binomial $(p + q)^n$. For the occurrence of 8 cases the appropriate term would be

$$\frac{n(n-1)(n-2)(n-3)(n-4)(n-5)(n-6)(n-7)p^8q^{n-8}}{1.2.3.4.5.6.7.8}$$

This would be equal to 0.0000013, where $n = 175$, $p = 0.00441$, and $q = 0.99559$. This means that there is only one chance in a million of getting 8 cases of a condition by chance alone in a group of 175 where the standard rate of incidence is 0.441 per cent. The observed difference in incidence rate is therefore significant.

DISCUSSION

It is obviously impossible to gauge accurately the amount of protection that

individual radiologists take against direct and scattered radiation, although such an analysis would be desirable from the standpoint of this study. It is a known fact that all of the radiologists here reported as having died of leukemia had been practising radiology for many years. It is outside the scope of this paper to discuss the effects of radiation on the various elements in the blood and blood-forming organs. For this, the reader is referred to an excellent review by Dunlap (16).

If it is assumed that a relationship exists between prolonged exposure to radiation and the development of leukemia, then the fact that a certain percentage of non-radiological physicians are exposed to radiation would tend to increase the validity of the attempted demonstration of such a relationship by the present statistical study, since this factor, if it had any effect at all, would tend to increase the incidence of leukemia in non-radiologists.

Since all radiologists are exposed to a greater or lesser amount of secondary radiation, and occasionally even to primary rays, and since radiation has a biologic effect, it would be desirable to have the causes of death, and perhaps the major illnesses, of all radiologists carefully recorded in some central agency, so that when sufficient data had accumulated, any possible relationship between prolonged exposure to radiation and various disease processes could be studied.

SUMMARY

1. During the past fifteen years 8 radiologists in the United States have been reported as dying of leukemia.

2. These 8 cases are added to the 23 cases of leukemia reported in the world literature as occurring in persons exposed to radiation over a prolonged period, which are briefly reviewed; a few of the latter group are not well substantiated.

3. The incidence of leukemia in radiologists for this fifteen-year period is over ten times as great as the incidence of this condition in non-radiological physicians during the same time.

4. Statistical analysis shows that this finding is significant, *i.e.*, the increased incidence of leukemia in radiologists is far greater than can be accounted for on the basis of chance alone.

NOTE: The author wishes to acknowledge with thanks the assistance rendered by Miss Ann M. Fox, news editor of the *Journal of the American Medical Association*, in making available data from her files that did not appear in the *Journal*.

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Leukemia in Mice Following Exposure to X-Rays[1]

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THE POSSIBLE causal relation between exposure to x-rays and the occurrence of leukemia has been studied in only a few instances. For this report we shall follow the procedure of Richter and MacDowell (1) and use the term leukemia in the broader sense. to cover not only the myeloid, lymphoid, and monocytic forms, but also lymphomatosis, lymphosarcoma, lymphadenosis, and pseudoleukemia.

Krebs, Rask-Nielsen, and Wagner (2) appear to have been the first to carry out investigations on the induction of leukemia by x-rays. With single whole body exposures of 400 r, given to large numbers of mice, the incidence was raised from 0.06 in the controls to 0.35 per cent. Thus, while the actual incidence was still low, the increase amounted to nearly six-fold. Furth (3) gave single whole body treatments of approximately 400 r and found a slight but nevertheless definite increase in leukemia of both myeloid and lymphoid types. Hueper (4), using hard x-rays, gave repeated general body treatments to mice, doses up to 480 r being administered in a six-week interval. He observed an incidence as high as 74 per cent in animals in which, he states, the normal incidence was 19 per cent. Furth and Furth (5) irradiated the whole bodies of mice with single or repeated doses of 200 to 400 r and observed an increase in myelosis as high as eight-fold, and of mediastinal lymphomatosis as high as seven-fold. The actual incidence of lymphomatosis and myelosis, however, did not exceed 13.9 and 7.6 per cent, respectively.

Descriptions have been given and summaries made (6) of the occurrence of leukemia in persons occupationally exposed to high-energy radiations. Similarities have been pointed out between radiation-induced lesions of the skin and those in hematopoietic organs which later become neoplastic. The plausibility of the idea that radiation may induce leukemia has been openly discussed, but as yet adequate statistical evidence showing a greater occurrence of leukemia among exposed persons is lacking. Henshaw and Hawkins (7) have found the incidence of leukemia in physicians to be approximately 1.7 times greater than in white males of the general population. On the assumption that physicians as a group are more exposed to high-energy radiations than white males of the general population, this observation may be said to be in accord with the findings with experimental animals, but since the higher incidence of leukemia in physicians may be accounted for by other factors, radiation is not fully indicted as the causal agent.

In the studies with animals previously reported, doses of 200 to 400 r were used, and not much attention was given to the number or frequency of treatments. Hence, while some positive evidence was obtained indicating that radiation may induce leukemia, the actual incidence was never high (except in Hueper's experiments, in which the strain used had a high spontaneous incidence), and it would appear that the optimum conditions for induction had not been found. In our experience with different strains of mice (8), doses of 200 to 400 r applied acutely to the whole body were sufficient to produce a modification of the peripheral blood picture and marked destruction of hematopoietic tissues. It seemed plausible, then, that the increased incidence of leukemia might be related to the destruction of hematopoietic tissues and that a greater increase might be obtained by increasing the

[1] Read by title at the Twenty-ninth Annual Meeting of the Radiological Society of North America, Chicago, Ill., Dec. 1–2, 1943.

TABLE I: NUMBERS OF DEATHS AT DIFFERENT TIMES AFTER TREATMENT WAS BEGUN

Type of Disease	Months After Treatment						Total Number of Deaths	Per Cent Leukemia
	1–3	4–6	7–9	10–12	13–15	16–18		
Males (28)								
Leukemia	0	0	1	5	1	0	7	25.0
Other causes	1	0	4	3	5	8	21	
Females (29)								
Leukemia	0	0	7	2	1	0	10	34.5
Other causes	1	0	5	7	5	1	19	
TOTAL							57	29.8

amount of destruction. With this in mind, experiments were planned whereby considerable damage could be produced in blood-forming organs during an appreciable interval of time.

METHODS AND MATERIAL

Since single doses of 400 r are lethal to some animals, and inasmuch as return to a normal blood picture after such exposures requires three to four weeks or more, it was decided to use doses of 200 r repeated at four-week intervals as long as this could be done without too severe an effect on the health of the animals. Arrangements were also made to obtain continuous leukocyte records on some of the animals.

C57 Black mice obtained from the Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Maine, were used exclusively for the experiment. This strain of mice was used, since it was known to have a spontaneous incidence of leukemia not greater than 10 per cent (9). Fifty-seven animals (28 males and 29 females) were exposed to radiation. Treatment was begun when the animals were three to four months old. A similar group of 60 animals was maintained under the same conditions (except for treatment) as controls. Total and differential leukocyte counts were made on 10 animals of the experimental and control groups at fortnightly intervals.

The x-ray equipment used consisted of the dual-tube simultaneous cross-firing apparatus available at the National Cancer Institute. The conditions used were: 200 kv., 20 ma. 0.5 mm. copper and 1.06 mm. aluminum filter and a distance of 38 cm. from each target. The intensity at the level of the mice was 121 r per minute as measured in air with a Victoreen ionization chamber. Hence, the exposure time for delivering a dose of 200 r was 1.65 minutes. During treatment the mice were held in a shallow, light-weight celluloid tray. Following treatment they were kept under constant observation until death, at which time they were examined grossly and histologically for leukemia. The data to be given are derived exclusively from the present experiment. Some of the details concerning the gross and histologic changes, however, are drawn in part from other more extensive experiments now in progress.

RESULTS

Table I shows the number of animals dying with leukemia at different times after treatment, the data for males and females being shown separately. Deaths from leukemia occurred during the interval of seven to fifteen months after irradiation, for the most part between the seventh and twelfth months. As shown in the last columns, 7 of 28 males, or 25.0 per cent, died with leukemia and 10 of 29 females, or 34.5 per cent. While these figures indicate a greater frequency in females, the difference for these limited data is not regarded as significant. By averaging the values for males and females, a figure of 29.8 per cent is obtained. In a similar group of 60 control animals maintained under similar conditions, only 4, or less than 7 per cent, died with leukemia during a corresponding period.

The gross and histologic picture as seen at death showed differences as well as simi-

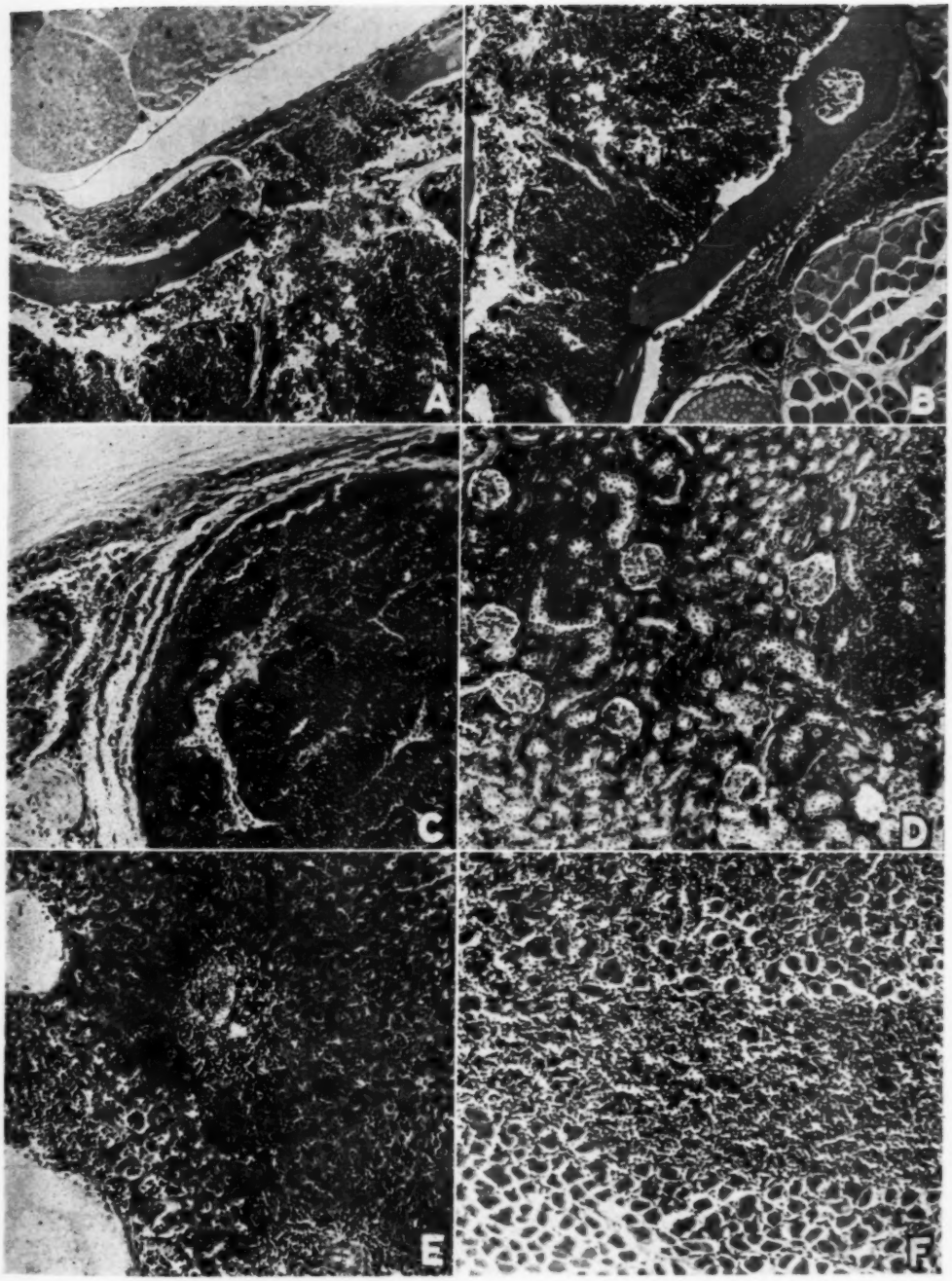

Fig. 1. Leukemic invasiveness in different organs. *A*. Meninges. *B*. Paravertebral connective tissue. *C*. Lymph node capsule and connective tissue. *D*. Kidney. *E*. Liver. *F*. Skeletal muscle (near sternum). Hematoxylin and eosin. × 100.

larities in the various animals. Mediastinal masses in the region of the thymus were most frequently seen. These sometimes measured 8 to 12 mm. in diameter and often formed apron-like extensions which surrounded and became attached to the heart and lungs. In some instances the masses were attached to and infiltrated the chest wall. This thymic enlargement was in some cases accompanied by general enlargement of lymph nodes and spleen and an increase in young leukocytes in the circulating blood, but more often only thymic enlargement and slight general lymph node enlargement were observed. In occasional animals the thymic enlargement was absent while lymph node or splenic hypertrophy indicated the leukemic state. As will be shown below, a modified blood picture sometimes accompanied the disease, but more often it did not.

The only unvarying characteristic which was depended upon fully for diagnosis was invasiveness of leukocytes from normal sites into adjacent tissues. Figure 1 shows typical examples. *A* and *B*, respectively, show invasion of the meninges and of the paravertebral connective tissue from vertebral bone marrow. *C* shows invasion of the capsule and connective tissue surrounding an axillary lymph node. *D*, *E*, and *F*, respectively, show leukemic infiltration of kidney, liver, and skeletal muscle (near sternum). The degree of invasiveness varied from animal to animal, some showing only traces. The line of separation between the normal and diseased tissue was, in fact, not sharply defined, making diagnosis difficult. For the table above, all cases listed as positive showed extensive invasiveness and all questionable or borderline cases are listed as negative.

In order to illustrate further the necessity of depending upon invasiveness for diagnosis, one case in particular will be described. Shortly before death in the eighth month after treatment, this animal exhibited paralysis of the hind legs, the only case of this kind seen. The peripheral blood picture was negative at autopsy, and all organs displayed a normal appearance with the possible exception of the mesenteric lymph node and the thymus, which were slightly enlarged. The gross picture, therefore, gave no explanation of the paralysis nor any clue as to the cause of death. Histologic sections of the spine, however, revealed a hyperplastic vertebral marrow, a packing of the meningeal spaces with leukocytes, and invasion of the paravertebral musculature. The paralysis was thus readily accounted for, and the animal was classed as a positive leukemia case.

Figure 2 shows continuous blood records on 3 representative animals. *A* is for a non-irradiated control animal and *B* and *C* are for animals that received doses of 200 r at intervals of four weeks, as indicated by the arrows. Continuous blood count records were made on 5 females and 5 males from each group, and attempts were made to obtain counts for at least a short period on most of the animals shortly before death. The graphs in Figure 2 were selected for presentation because they are typical of the blood records obtained.

In graph *A*, the leukocyte level ranges generally between 8,000 and 13,000 cells per cubic millimeter of whole blood. Only once was this animal found to have a count significantly higher than 15,000. In our experience generally, leukocyte counts in the range of 20,000 to 30,000 have been found occasionally in animals which were presumably normal, but such levels were never sustained for periods of several days or weeks. In C57 Black mice the lymphocyte level runs higher than that of the neutrophil, as a rule. A few (5–10 per cent) younger forms were present normally, but only rarely were blast forms seen.

With reference to the treated animals, *B* and *C* differ from each other and also from the controls. During treatment the changes were generally the same for both *B* and *C*, consisting of a gradual development of leukopenia. When five or six treatments had been completed, the leukocyte level was in the range of 1,000 or below, both lymphocyte and neutrophil levels being markedly affected. Beginning soon after the last treatment, or perhaps shortly

before (*B*), some evidence of recovery developed. In the case of *B*, recovery never went beyond the normal level and the lymphocyte and neutrophil counts continued to be generally characteristic of normal animals. *C*, on the other hand, disease in this case was considered to be typical leukemia with involvement of the peripheral blood. Animal *B* at autopsy was also found to have a primitive type cell invading many tissues. The photomicrographs shown in Figure 1 were ob-

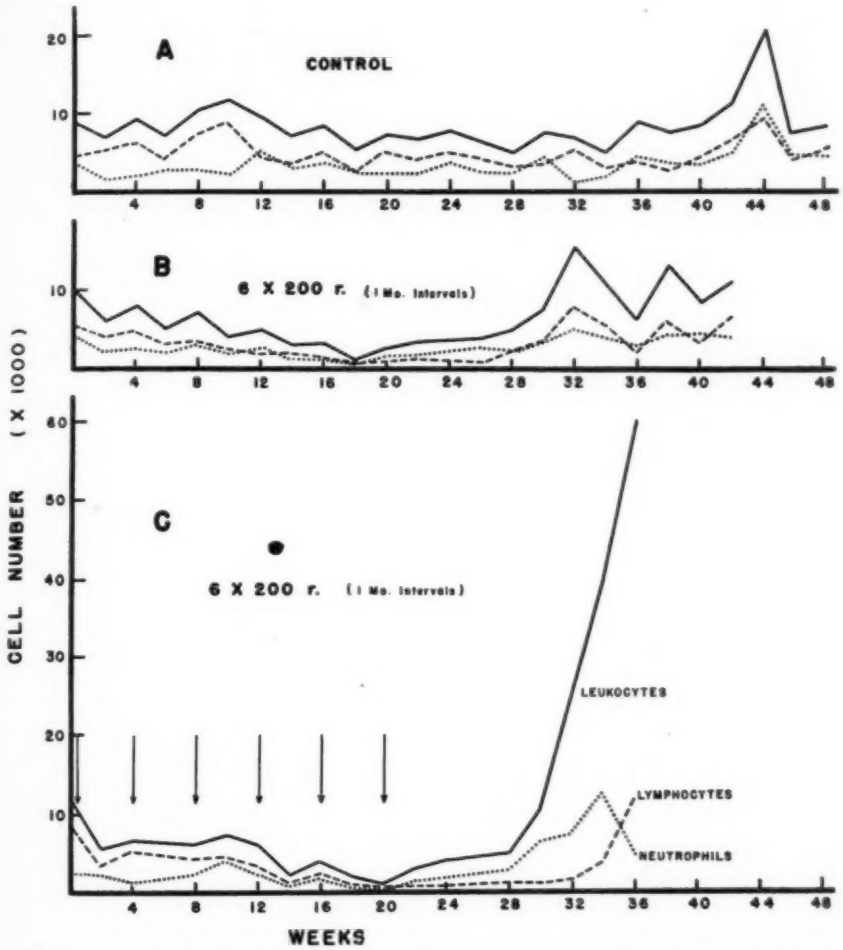

Fig. 2. Continuous blood records on individual mice. *A*. Control. *B* and *C*. Experimental animals receiving 200 r exposures at intervals indicated by arrows. The solid, dash, and dotted lines represent absolute numbers of leukocytes, lymphocytes, and neutrophils, respectively.

after having a fairly normal recovery, suddenly showed an extensive rise in leukocyte level, the predominant cell type being primitive in character. Histologic sections taken at autopsy showed this cell form to be invading the tissues of many organs. The tained from this animal. In this case, the disease was also considered to be leukemia but not involving the peripheral blood. Protocols from the present experiment and others now in progress contain several records like *C* and several like *B*. Actually

the *B* type has been seen more often than *C*, and some of these show even less fluctuation near the end than indicated in *B*.

DISCUSSION

The work described here gives further evidence that the incidence of leukemia can be increased in laboratory animals by exposure to ionizing radiations. The incidence obtained with the methods used was very nearly 30 per cent. With the exception of Hueper's figure (based on animals with a high spontaneous incidence) this value is the highest yet obtained. Since the normal incidence of leukemia in the strain of mice used, however, was 7 per cent, it is obvious that the increase amounted to approximately four-fold. In this respect our findings lie intermediate among those of the previous workers.

In the present experiment, it was our aim to employ doses definitely injurious to the hematopoietic organs and tissues and to carry the damage as far as the vitality of the animals would permit. As made evident by the curves (Fig. 2), doses of 200 r produced depressing effects on the leukocyte level and the effects were to some extent additive when treatments were given at intervals of four weeks. From previous experience (8) it was known that doses of 200 r induce extensive damage and destruction in hematopoietic organs, particularly to free lymphocytes, and that periods of three to six weeks or more are required for return to normal. After four to six 200 r treatments had been given in the present experiment, the leukocyte numbers were reduced to dangerous levels (1,000 per cubic millimeter or less), and the animals were uniformly in a cachectic state. For these reasons the treatments were discontinued when six had been given.

The figures given indicating the incidence of leukemia are conservative. Only unquestionable cases were classed as positive, all others being considered as negative. A few animals died early of intercurrent disease and some were cannibalized to the point that satisfactory examinations could not be made. It may be presumed that in some of these leukemia would have developed if they had lived long enough, but this group together with the borderline cases accounted for less than 20 per cent of the animals. At least half of the animals showed no evidence of the disease, thus making it plain that a still greater incidence might be obtained with more carefully planned treatments. Other experiments are in progress testing other treatment procedures.

The over-all picture thus far obtained is as follows: The radiation produces destructive effects in the blood-forming tissues, changes which become reflected in the peripheral blood as leukopenia. If the damage is not too severe, recovery takes place over a period of weeks or months. Either associated with or following the regenerative process, hyperplasia and neoplasia of hematopoietic tissues develop, which may or may not have manifestations in the peripheral blood. When true leukemia does occur, the onset is sudden and the rise in leukocyte level is rapid (Fig. 2, *C*). A number of continuous blood records have been kept for treated animals that developed true leukemia, and this picture was invariably obtained. Since the animal *B* (Fig. 2) showed leukemic infiltrations, it might be argued that the oscillations in leukocyte level between thirty and forty weeks constituted evidence of leukemic manifestations in the peripheral blood. This might indeed be the case but, since the differential picture was little if any altered and since the leukocytosis did not exceed limits often seen in untreated animals, this possibility is regarded as unlikely. Other records have, in fact, been obtained for leukemic animals which showed no such oscillations. It seems proper, therefore, to regard manifestations in the peripheral blood as secondary effects. Hyperplasia and invasiveness were seen without increased leukocytosis in the peripheral blood, but extensive leukocytosis was never observed without hyperplasia and invasiveness. The site of the disease has appeared problematic, with a slight predilection for the thymus. Hyper-

trophy occurred in one group of hematopoietic organs in one animal and in another group in a different animal, suggesting that the various blood-forming organs have about the same susceptibility irrespective of location.

Little has been said thus far regarding cell types. In general, the forms were undifferentiated and indeterminate. For the most part, they were uniformly similar in any given animal. Perhaps the most significant observation was that the cell type was not the same for all animals, although the same treatments had been received under the same conditions in all cases.

SUMMARY

1. X-rays in doses of 200 r were applied acutely to the whole bodies of C57 Black mice at intervals of four weeks for twenty weeks, and the animals were watched for the occurrence of leukemia.

2. Leukemic disease was found in approximately 30 per cent of the treated animals, but in only 7 per cent of non-irradiated controls.

3. Continuous blood records showed a general depression of leukocyte level during treatment, followed by a slow return to normal after treatments were discontinued. In some animals, the recovery extended into a marked leukocytosis, and these animals at death were invariably found to have leukemic infiltrations.

4. Hyperplasia of hematopoietic organs and invasiveness were seen in all animals recorded as positive, but the distribution of such conditions varied from animal to animal.

5. Primitive cells were seen as the predominant type in all cases. For the most part, the type was uniform in any one animal but varied from one animal to another.

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Industrial Radiation Hazards[1]

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THE PRESENT industrial expansion has resulted in vastly increased use of x-rays and radium in the examination of materials and manufactured products. Today these applications of roentgen and gamma rays have reached a volume exceeding that of medical radiology and the exposure of a thousand films a day is not unusual for an industrial equipment.

In order to avoid a repetition of the injuries suffered by the pioneers of medical radiology, it is essential that the industrial users be thoroughly acquainted with the detrimental effects of radiation. At the same time they should have sufficient understanding of the protection problem to realize that with proper safeguards their work does not entail greater hazards than occur in other fields. These safeguards consist essentially in reducing the unwanted, or stray, radiation to a negligible amount, thereby preventing superficial injuries to the skin and hair as well as harmful systemic changes, particularly in the blood and genetic cells.

On the basis of experiences gained over a period of years in medical radiology, it was estimated that a person may be exposed without danger to 0.2 r per day (or 10^{-5} r per second). This amount, *the daily tolerance dose*, does not, however, allow for the special conditions of industrial radiology or for possible genetic effects necessitating a greater margin of safety. The value of 10^{-5} r per second is based on a thirty-five-hour week, while today many industrial employees work fifty hours or more. Furthermore, the wider beams of radiation and higher voltages frequently used industrially increase the volume dose, that is, the total amount of radiant energy absorbed by the body. Geneticists (5) have advocated that the tolerance dose be reduced to 0.02 r per day, or less, to avoid possible damage to future generations due to the cumulative effects of radiation on the gonads. Yet that point of view is not supported by the fact that the human race has been exposed for ages to cosmic radiation, at the rate of about 0.03 r per year. This question, therefore, is by no means settled and, until more experimental and clinical evidence is available both on the genetic and the volume dose effects, it may be well to apply a factor of safety according to the voltage used, the size of field, and the type of person to be protected. Obviously, better shielding should be provided for x-ray and radium workers than for persons only infrequently exposed to radiation.

This report is a summary of the writer's experiences gained from stray radiation surveys of about fifty industrial installations using voltages from 30 up to 1,000 kv. and gamma rays. The instruments used in these measurements were similar to those previously described (3, 4) and included ionization chambers with air volumes of 435 c.c. and 6,000 c.c. as well as Geiger-Müller counters.

PROTECTION AGAINST DIRECT RADIATION

Stray radiation may be reduced materially by enclosing the x-ray tube in a so-called rayproof housing provided with a small aperture practically limiting the primary rays to the useful beam. The protective qualities of such enclosures have been discussed in our earlier papers (3, 4). It was found that the stray radiation from "rayproof" tube holders generally is less than 1.0 r per hour at a target distance of 1 meter and with the x-ray tube operating at its maximum continuous rating. This is ample protection where

[1] Read by title at the Twenty-ninth Annual Meeting of the Radiological Society of North America, Chicago, Ill., Dec. 1–2, 1943.

additional shielding is provided in the walls of the x-ray room but still insufficient to permit manipulation of the tube enclosure while the tube is energized even if the aperture is closed by means of a shutter.

Further protection must be provided against that part of the useful beam not absorbed by the object and against the secondary rays emitted by any material exposed to radiation. The amount of protection needed will depend mainly upon the tube voltage used, the milliampere-minutes of exposure, and the distance to the x-ray tube target. As the dose varies inversely as the square of the distance, this last factor has a far greater significance than is generally realized. Of the various materials suitable as barriers to the rays, lead is generally the most economical, although concrete may be used to advantage for higher voltages or where it already is part of the building construction, as in floors and ceilings. The International Commission on X-Ray and Radium Protection has formulated certain minimum protection requirements (6), based primarily on medical applications without consideration of the special conditions of industrial radiology. The recommended lead protective values are given for different x-ray tube voltages, without taking into account the milliamperage, target distance, and exposure time. As was demonstrated previously (3, 4), compliance with these rules has given a high factor of safety for medical applications. Better protection, however, and greater economy, may be attained for industrial installations by considering all the factors affecting the thickness of lead required.

In Figure 1 is shown the relationship between the required lead thickness and target distance for various voltages, assuming the x-ray tube is operating at 10 ma. for fifty hours a week and the daily tolerance dose is 0.1 r as recommended by the National Bureau of Standards (9). This chart indicates graphically the results of our absorption measurements made on equipment commonly used industrially. The values for 125 kv. and less were obtained with x-ray tubes having an inherent filtration equivalent to 0.5 mm. Al and energized by half-wave two-valve generators. The self-contained half-wave type of equipment with an inherent filtration of about 3 mm. Al was used at the higher voltages. The dosage rates of different installations checked within 10 per cent and are generally somewhat lower than those obtained by Binks (1). This might be expected, as his values are for constant potential, while ours are for pulsating potential, which is the voltage wave-form of most industrial x-ray units used in this country.[2] It is interesting to note that we both obtain a relatively higher lead thickness for 100 kv. than indicated in the International Recommendations. This chart assumes an average exposure of 5,000 milliampere-minutes a day, which is generally the maximum with present x-ray tubes for one shift, and considerably above that used with any of those examined.

It should be noted that even a marked change in the milliampere-minutes does not alter materially the lead protection required. For instance, doubling the exposure at 100 kv. increases the lead thickness only 0.2 mm. and at 200 kv. only 0.4 mm. This is illustrated in Figure 2, where the data are given for different daily exposures expressed in milliampere-minutes or milliamperes for continuous operation. This chart, too, is based on a daily tolerance dose of 0.1 r but may be used for any other value merely by multiplying the milliampere-minutes used by the desired factor of safety. The required lead thickness is obtained by drawing a horizontal line through the intersection of the two diagonal lines representing the target distance and the daily exposure used. The vertical projection of the intersection of this horizontal line with the curve for the applied voltages will then indicate the required lead thickness.

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[2] Comparative measurements at 200 kv. constant potential checked closely with Binks' data and showed an increase of only 5 to 10 per cent in lead thickness over pulsating potential.

Example: An x-ray tube is operating 8.3 hours a day at 200 kv. and 5 ma. What lead thickness is required at a target distance of 5 meters? *Answer:* Since $8.3 \times 60 \times 5 = 2{,}500$ milliampere-minutes, follow the horizontal line from the intersection of the 5-meter and the 2,500-milliampere-minute lines till it crosses the 200-kv. curve; then follow the vertical line to 3.0 mm. lead, which is the thickness required.

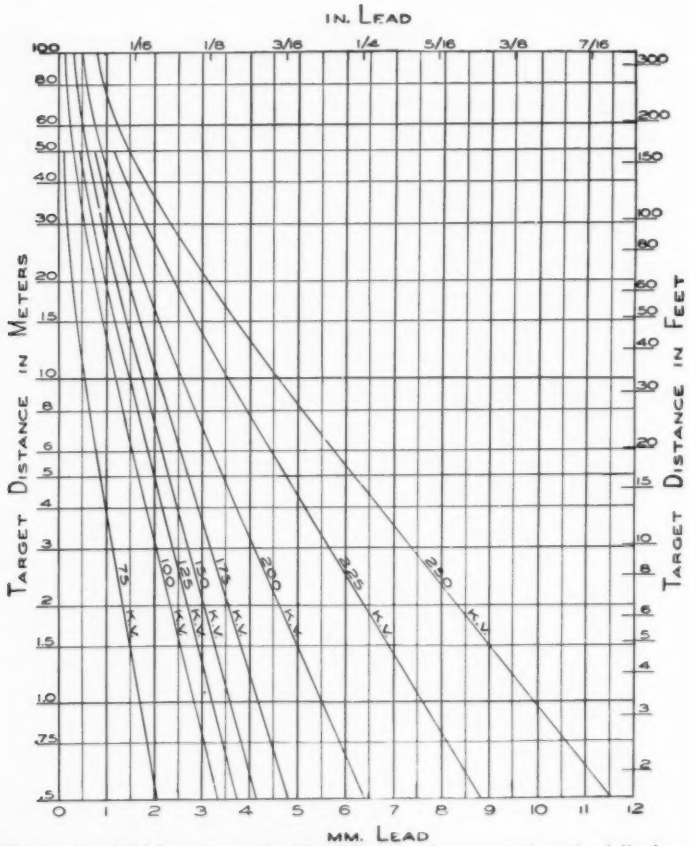

Fig. 1. Lead thicknesses required for different voltages to reduce the daily dose to 0.1 r for 10 milliamperes continuous operation.

In planning industrial protection it is advisable to assume that the x-ray tube is operating at its maximum continuous rating. Experience has shown that most installations eventually operate at much higher outputs than originally planned. Where the personnel are exposed to stray radiation from several x-ray tubes operating simultaneously, the lead shielding must be increased accordingly.[3] If the tubes operate at the same voltage, the shielding for *each* must be calculated for the total exposure of *all* the tubes.

Most of the reported industrial radiation injuries have been caused by ignorance or neglect rather than insufficient thickness of lead shielding.[4] Many of the routine x-ray examinations are carried out by non-

[3] This is of particular importance in plants manufacturing x-ray tubes, or other electronic tubes emitting x-rays, where large groups of these are being operated for pumping or test.

[4] The effects of systemic injuries caused by prolonged exposure to weak radiation may not show up for years. The fact that nothing has happened is not proof that the installation is safe.

technical workers, and the possibility of accidents is great unless the equipment is made foolproof with automatic means of preventing exposure to direct radiation; this is especially true of x-ray diffraction units, which are now used in large number for orientation of crystals. Of the four types of units examined, only two provide *automatic* shielding to prevent exposure to the hands of the operator while placing or removing the crystal. With the other two types, a careless worker might readily have her fingers exposed to the intense direct beam of unfiltered radiation, usually 30 kv. and 20 ma. with a target distance of only 10 cm. There are already several reports of skin ulcers caused by such conditions.

Routine fluoroscopic inspections are usually carried out with apparatus designed for the particular type of object to be examined. To obtain maximum protection, both the x-ray tube and object should be located in a shielded enclosure with a lead-glass window[5] for observation of the fluoroscopic screen. Where the target screen distance is short, it may be necessary to use a greater thickness of lead shielding than indicated in the International Recommendations. The values may be determined from the graph of Figure 2. Door switches should be provided to break

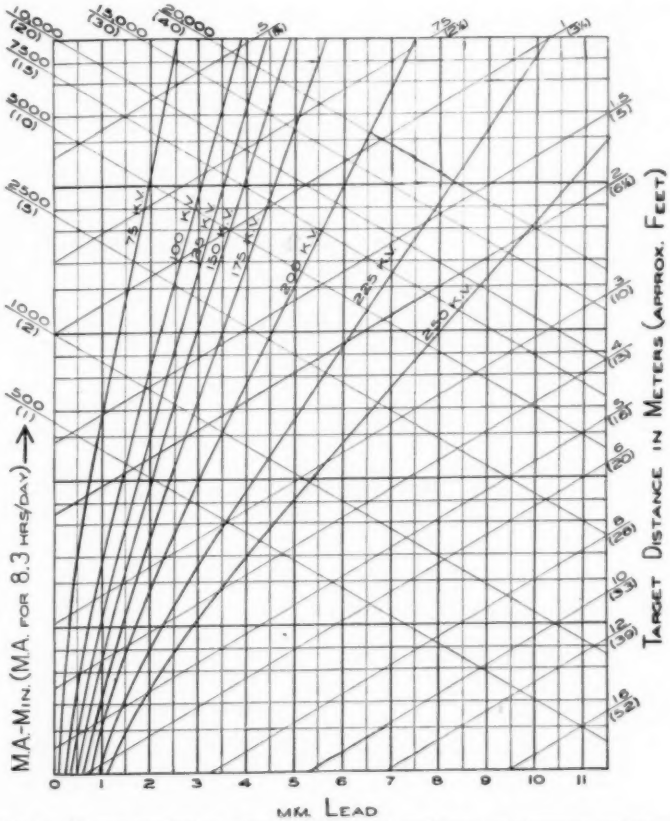

Fig. 2. X-ray protection chart for different voltages, milliampere-minutes and distances. The daily tolerance dose is assumed to be 0.1 r.

[5] The lead glass should have the same "lead equivalent" as the wall in which it is mounted. By its lead equivalent is understood the thickness of lead which has the same absorption for a particular radiation as the lead glass.

the high-tension circuit and thereby prevent exposure to the direct beam while the enclosure is open.

Unfortunately, occasional fluoroscopy is often carried out with discarded medical equipment, with protection far from adequate for industrial purposes. Many of the superficial radiation injuries have taken place with apparatus of the makeshift type, often because the operator has moved the object with his unprotected hand in the direct beam. Even with standard lead rubber gloves (lead equivalent 0.5 mm.) this is a dangerous procedure for voltages above 75 kv. and is not advisable at any voltage.

Over-exposure to direct radiation is unlikely with radiographic installations where both the x-ray tube and the object are completely enclosed in shielded rooms or booths. Of installations of this type which were examined, only two had inadequate protection against the direct beam. Some had excessive rayproofing, such as lead lining of outside walls, although they were far removed from other buildings.[6]

The use of separate shielded enclosures for radiographic study of large objects is not always practical, as it would require enormous rayproofed rooms and would necessitate additional handling of the material. Instead, a completely lead-lined control booth provides protection to the operator, with the beam directed in such a way that the exposure to other workers is well below the tolerance dose. In some plants, adequate protection has been obtained by using the object as the only barrier to the direct beam. This is possible if the film is placed inside the object, as is the case in radiographing welds of high-pressure vessels or pipes; otherwise, the amount of radiation required to expose the films would cause excessive stray radiation. It is obvious that with this arrangement a large group of workers might readily receive radiation injuries unless the x-ray tube were energized only when the object covered the whole aperture. Measurements at such installations indicate that with 400 kv. and 5 ma. the daily dose for eight hours' operation, without any object in place, is almost 200 r at a target distance of 10 feet, and 0.1 r at a distance of 450 feet. With the usual type of object in place, the daily dose was only 0.2 r at 10 feet. Actually the stray radiation was considerably less, as the average cumulative exposure time was only a few hours a day.

[6] It may sometimes be necessary to rayproof outside windows and walls to protect occupants of neighboring buildings. Such protection eliminates, also, "back-scatter" from nearby walls, which may cause excessive exposure to people in adjoining rooms.

PROTECTION AGAINST SCATTERED RADIATION

Most of the cases of inadequate protection investigated were due to insufficient shielding against the scattered rays emitted by any material exposed to radiation, such as the object being radiographed or the floor, walls, and ceiling of the x-ray room. While scattered radiation is only a small fraction of the incident radiation, less than 1.0 per cent, it may readily cause excessive stray radiation unless proper shielding is provided. The thickness of lead needed may be estimated from the chart in Figure 2 by dividing the actual milliampere-minute exposure by 100 and then using the chart in the same way as for direct radiation. The value thus obtained will be on the safe side where "rayproof" tube enclosures are used. Greater accuracy may be secured by considering all the conditions of each case and the lower penetrability of the scattered rays. Taylor (12) and Binks (1) have discussed this subject in detail and reference should be made to their papers. At one installation where the x-ray tube was mounted in an open lead-glass bowl, the stray radiation was about 0.5 r per hour at the operator's position. This was caused by scattering from the ceiling, as the lead protection of the wooden partition extended up only about six feet. The source of stray radiation was located by means of a Geiger-Müller counter constructed to give directional effect.

As scattered radiation is approximately proportional to the area irradiated, it is important to limit the cross section of the direct beam to that actually required. This is often neglected, although in some instances it has been possible to cut the stray radiation in half merely by adding a lead diaphragm to the aperture of the tube. Another advantage of reducing the scatter is the resultant improvement in the quality of the radiograph.

get and with maximum field size.[7] The ratio of the stray to the direct axial radiation, both measured through 18 inches of concrete, is about 5 per cent for the same target distance. The stray radiation was determined perpendicularly to the central beam at the level of the target and included primary radiation not absorbed by the tube housing as well as the scatter from the floor. Further tests showed that the stray radiation was due almost entirely to

TABLE I: X-RAY PROTECTION REQUIRED TO REDUCE THE DIRECT RADIATION TO 0.1 R PER DAY

(The protection is given for different exposures per day indicated in milliampere-minutes and corresponding milliamperages for continuous operation)

Distance		400 kv.								1,000 kv.							
		1,500 ma.-min. (3 ma.)				2,500 ma.-min. (5 ma.)				500 ma.-min. (1 ma.)				1,500 ma.-min. (3 ma.)			
Meters	Feet (Approx.)	Lead		Concrete		Lead		Concrete		Lead		Concrete		Lead		Concrete	
		mm.	in.	cm.	in.	mm.	in.	cm.	in.	mm.	in.	cm.	in.	mm.	in.	cm.	in.
1	3	17.5	11/16	30	11 3/4	18.5	3/4	31	12 1/4	...	...	...	...	...	...	...	...
2	7	14.9	5/8	26	10 1/4	15.8	5/8	27	10 3/4	...	...	88	35	...	...	105	41
3	10	13.4	9/16	24	9 1/2	14.3	9/16	25	9 3/4	...	...	77	30	...	...	93	37
4	13	12.2	1/2	22	8 1/2	13.2	1/2	23	9 1/4	...	...	68	27	...	...	84	33
5	16	11.3	7/16	21	8	12.4	1/2	22	8 3/4	...	...	63	25	...	...	78	31
6	20	10.7	7/16	20	7 3/4	11.7	1/2	21	8 1/4	73	2 7/8	58	23	...	...	73	29
8	26	9.6	3/8	18	7	10.5	7/16	19	7 1/2	67	2 5/8	52	21	...	...	65	26
10	33	8.7	3/8	17	6 1/2	9.7	3/8	18	7 1/4	63	2 1/2	46	18	73	2 7/8	58	23
20	66	6.1	1/4	13	5 1/4	7.1	1/4	15	5 3/4	49	2	...	...	60	2 3/8	43	17
30	98	4.6	3/16	11	4 1/4	5.5	1/4	12	4 3/4	41	1 5/8	...	...	52	2	...	...
40	131	3.5	1/8	9	3 1/2	4.4	3/16	10	4	35	1 3/8	...	...	46	1 7/8	...	...
50	164	2.7	1/8	7	2 3/4	3.6	1/8	9	3 1/2	30	1 1/4	...	...	41	1 5/8	...	...

A large volume of radiography is done by means of turntables, sliding trays, and other automatic arrangements to bring the film and objects into position. Such devices require expert construction to avoid scattered radiation and should be provided with interlocking switches.

400-KV. AND 1,000-KV. INSTALLATIONS

Much more attention has been given to the protection problem for higher voltages, and as a result the factor of safety is generally high. In Table I are presented the results of our measurements at 400 and 1,000 kv. The concrete thicknesses for 400 kv. have been calculated from our lead values, with the conversion factors of Singer, Taylor, and Charlton (11). The measurements at 1,000 kv. were made with the transmission-type target and with maximum field size.[7] The ratio of the stray to the direct axial radiation, both measured through 18 inches of concrete, is about 5 per cent for the same target distance. The stray radiation was determined perpendicularly to the central beam at the level of the target and included primary radiation not absorbed by the tube housing as well as the scatter from the floor. Further tests showed that the stray radiation was due almost entirely to direct rays from the tube and generator housing, rather than from the floor.

RADIUM PROTECTION

The safe use of gamma rays for industrial radiography requires precautions similar to those used in radium therapy. These are given in detail in the recommendations of the National Bureau of Standards (8) and recently have been summarized by Quimby and Pool (10). There are, therefore, only a few points which need be stressed here. Structural shielding is rarely of value in the industrial applications of gamma rays. Even a 1-inch lead barrier will transmit about 25 per cent of the incident radiation, and the same reduction may be obtained by merely doubling

[7] The protection requirements will be less for smaller fields and where the tube is operated only with the object in place.

the radium distance, as the dosage rate of gamma radiation also varies inversely as the square of the distance. Shielding, therefore, is used mainly while the radium is not in use and can be stored in lead containers. The amount of lead required will depend on the amount of radium, the distance, and the cumulative time of exposure. The thickness may be obtained directly from the Failla protection chart (8) or estimated from certain simple factors. The dose of 1 gm. of radium, filtered through 0.1 cm. lead, is about 6.7 r for eight hours at a distance of 1 meter. Each half an inch of lead cuts the radiation approximately in half. To reduce the daily dose to 0.1 r, the tolerance dose, would therefore require about 3 inches of lead under the above conditions.[8] Without shielding, the distance would have to be increased to about 8 meters to obtain the same reduction in dose. The area within that radius is considered the danger zone and should be so marked.

DISCUSSION

The results of this study indicate clearly that a higher factor of safety and greater economy may be obtained in planning industrial x-ray protection on the basis of all the factors involved instead of simply the tube voltage, as has been the general practice in the past. Such determinations have been simplified by charts provided for the usual range of voltage, milliampere-minutes, and distance. The obtained lead thicknesses are based on the average dosage rates of industrial equipment, as the small variation between different generators has no significant bearing on the lead required.

Industrial radiation injuries are not necessarily eliminated by adequate structural shielding and safe equipment. Of equal importance are the training and practice of the technicians in safe operating procedures and their understanding of the fundamental technical and clinical aspects of protection, which not only reduces radiation hazards but also eliminates unfounded worries, so frequently caused by misinformation.

In order to maintain a high degree of protection, it is necessary to check periodically the stray radiation received by industrial x-ray and radium workers. This may be done most readily by means of dental films carried on different parts of the body for a period of one month. The dose received may be estimated by comparing the density of the test films with control films exposed to known fractions of a roentgen, using radiation of similar quality. Pocket ionization chambers should be used in place of the films where greater accuracy is indicated. Either method of stray radiation control serves also as an incentive to the personnel to avoid unnecessary exposure and at the same time gives them a sense of security when the stray radiation is proved to be negligible.

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[8] Where greater accuracy is required, reference should be made to the results in our paper "Protection Measurements of Lead Shielded Radium" (to be published).

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Clinico-Pathological Conference

ST. LOUIS UNIVERSITY SCHOOL OF MEDICINE

E. Lee Shrader, M.D., L. R. Sante, M.D., and W. A. D. Anderson, M.D.

HISTORY AND CLINICAL EXAMINATION

E. Lee Shrader, M.D.

A twenty-one-year-old white female entered the hospital on Feb. 4, 1943, complaining of abdominal pain which had its inception on Jan. 25, 1943. The pain at first involved the right lower quadrant and occurred chiefly in the evening but was sufficiently relieved by a hot-water bottle to permit sleep. Two days later, Jan. 27, it became more generalized and was associated with cramping and tenderness. No fever was present and the white count and differential count were normal. Paregoric and an enema, with bed rest, enabled the patient to return to work. On Jan. 31, she again had recourse to an enema for relief. On Feb. 3, she was seen by a physician and a gastro-intestinal x-ray examination was ordered. The pain at this time was colicky in nature and radiated to the back. On Feb. 4, her illness became so pronounced that she remained in bed. Syntropan and papaverine were administered. Emesis occurred for the first time on the evening of Feb. 4. The temperature was normal on admission.

Physical examination on admission showed the patient to be well nourished and well developed, in no acute distress. The findings were as follows:

Head: No evidence of pathological involvement.

Eyes: Pupils round, regular, and equal, reacting to light and accommodation; external ocular movements normal; no nystagmus; conjunctivae and sclerae appeared clear.

Nose and Ears: No abnormality.

Mouth: Excellent hygiene; mucous membrane well colored; tonsils not prominent; oropharynx not abnormal.

Neck: No lymphadenopathy or goiter.

Chest: Normal to inspection, palpation, percussion, and auscultation; diaphragm high on right side extending to 7th intercostal space posteriorly.

Heart: Contour and position normal; rate regular; blood pressure 118/68. A systolic murmur was present, loudest in the second intercostal space to the left of the sternum.

Abdomen: Full below the umbilicus but not tense and showing no rigidity. The point of greatest tenderness was in the midline between the umbilicus and pubis. A vaguely palpable mass about 5 cm. in diameter was present in the right lower quadrant; not freely movable and fairly tender. Tenderness was also noted on the left side in the lower quadrant. Normal peristaltic sounds were heard on auscultation. No inguinal lymphadenopathy was present.

Skin: No eruption or abnormality.

Extremities: Normal appearance.

Neuromuscular System: Achilles jerks present; no ankle clonus; plantar reflexes normal.

On Feb. 5, other examiners described the abdominal growth as in various locations, differing greatly in size and consistency, and giving widely different impressions as to its cause, such as ovarian cyst or twisted pedicle cyst. One examiner described the consistency of the mass as "that of old blood" and suggested the possibility of ruptured graafian follicle.

ROENTGEN EXAMINATION

L. R. Sante, M.D.

Roentgen examination of the gastro-intestinal tract was made on Feb. 5, 6, and 7. The esophagus, stomach, and duodenum did not show any evident abnormality. Hourly examinations were made of the passage of the opaque meal through the small bowel. No abnormality was noted until the three-hour examination, when unusual appearing intestinal loops were encountered in the lower portion of the abdomen. By the four-hour examina-

Fig. 1. Large circular loops of ileum, of increased caliber but uniform in size and devoid of mucosal markings. The inner border was smooth and an unbroken column of barium extended throughout this segment. No peristalsis was seen in this segment and barium mixture was forced slowly through it by pressure from above.

tion these had acquired definite characteristics (Fig. 1). Several large circular loops of small intestine were seen, much wider in caliber than normal intestine but uniform in size and devoid of mucosal markings, showing a perfectly smooth inner border and an unbroken column of barium through the entire extent of the region of involvement. There was no constriction at any place in the involved intestine or distal to it; no evidence of a "string sign." The barium mixture moved slowly through these distended loops by pressure from above, not by peristaltic action; once beyond the involved region, it seemed to pass more rapidly onward into the colon. The lesion was obviously not caused by intestinal obstruction from mechanical ileus of any sort nor by any granulomatous process filling the lumen. The thickened palpable loops of bowel, their circular contour, the loss of mucosal pattern, uniform enlargement in caliber, and lack of peristaltic action gave the impression of an infiltrating process invading the entire thickness of the wall of the intestines. Such a condition has been described in malignant infiltration of the intestinal wall, especially lymphosarcomatous involvement.

On Feb. 13 a cystoscopic examination was made but the ureteral catheters could not be introduced much above the ureterovesical junction. It was observed, however, that the bladder wall was pressed inward from above by some extrinsic mass.

OPERATION

On Feb. 15 the peritoneal cavity was opened by Dr. John W. Stewart. The cecum, appendix, and entire ascending colon were indurated and fixed. The mesentery was thick and large nodes were present. The process extended backward 24 inches on the ileum, in which area the bowel wall was indurated. An enterocolostomy was performed.

LABORATORY PROCEDURES

The blood counts on successive occasions were as shown. The bleeding time was 30 seconds; clotting time 1 minute 35 seconds.

Feb. 6: NPN 32. Blood sugar 80. Kahn and Kline tests negative.

Feb. 12: Cystoscopic bladder urine showed occasional leukocytes, epithelial cells.

Feb. 17: Urine culture: gram-negative bacilli; gram-positive bacilli; gram-positive diplococci.

Feb. 22: Heterophile antibody test negative.

Feb. 19: Sulfathiazole level 1 mg.

March 1: Total plasma proteins, 6.3 mg. per cent. A 4.1. G 2.2.

March 21: Total plasma proteins, 6.4 mg. per cent A 4.4. G 2.0.

March 23: Blood chlorides 346 mg. per cent.

POSTOPERATIVE COURSE

The patient ran a stormy postoperative course, with nausea, vomiting, abdominal distention, and fever ranging from 102 to 103.4°, with pulse as high as 120 and respiration 28.

On the basis of the clinical diagnosis of lymphosarcoma, palliative x-ray therapy

BLOOD COUNTS ON SUCCESSIVE OCCASIONS

Date	White Cells	Red Cells	Juvenile Cells	Stabs	Segmented	Neutrophils	Eosinophils	Basophils	Monocytes	Lymphocytes	Lymphoblasts
2-6	7,300	4.0	..	26	52	78	2	1	5	14	..
2-12	4,950	...	4	23	25	48	1	..	15	30	..
2-18	7,000	4.3	6	54	14	74	..	1	15	9	..
2-19	7,150	4.4	..	39	29	68	1	..	15	16	..
3-1	6,700	4.4	2	20	30	50	..	..	24	24	..
3-14	10,200	3.8	2	11	9	22	..	..	6	18	52
3-21	72,000	3.0	..	2	6	..	..	..	2	73	17

was started but had to be abandoned after a few treatments owing to the extremely critical condition of the patient. This continued to become worse until death on March 24.

PATHOLOGICAL REPORT OF AUTOPSY EXAMINATION

W. A. D. Anderson, M.D.

The body was that of a well developed but emaciated white female, with fairly advanced rigor mortis and a slight degree of livor mortis. The abdomen showed a recent midline suprapubic surgical scar extending to 4 cm. above the umbilicus. No tumors were evident on external examination, and superficial lymph nodes were not palpable. There was no peripheral edema.

No abnormalities of the pleural or pericardial cavities were evident. The peritoneal sac contained 200 c.c. of clear fluid of light yellow color. Several loops of small intestine were bound together by fibrinous bands, and the serosal surfaces of the bowel were dull and gray. The esophagus and stomach were unchanged, but the wall of the duodenum was thickened up to a maximum of 1.5 cm. This thickening was due to irregular and nodular accumulation of a soft grayish white tissue which seemed to involve mainly the submucosa and mucosa. The duodenal-jejunal junction and the proximal 12 cm. of the jejunum were similarly involved. The remainder of the jejunum and the proximal two-thirds of the ileum were unaffected. The distal third of the ileum and the appendix showed an irregular thickening up to a maximum of 1.5 cm., having an appearance similar to that in the duodenal region. An intact enterocolostomy connected the ileum above the region where the thickening began to the transverse colon. In the thickened portions of the small intestine there was some corresponding narrowing of the lumen of the bowel, but ulceration was not a prominent feature.

The lymph nodes of the abdomen and pelvis were all enlarged up to a diameter of 2 cm. They were of soft consistency and uniformly grayish white on their cut surface. About the pancreas, kidneys, aorta, and iliac vessels, the enlarged nodes formed irregular conglomerate masses of soft grayish tissue.

The heart, blood vessels, and respiratory tract showed no abnormality, but there was some enlargement of the mediastinal lymph nodes. The liver weighed 1,760 gm. and showed a mottling of the light brown cut surface by small rounded areas of grayish tissue. The spleen weighed 225 gm. and its cut surface likewise showed a mottling by translucent grayish tissue. The kidneys each weighed 150 gm. and showed lobulation by masses of soft grayish white tissue in the cortex. These grayish areas were irregular in size and shape, and many showed coalescence. The remaining organs showed no gross abnormalities.

The gross changes in the various organs were found microscopically to be due to growth of a polymorphic lymphoblastomatous tissue. In the small intestine and appendix the neoplastic growth involved mainly the mucosa and submucosa, but in areas where there was greatest thickening of the wall, the mucosa was largely replaced, the muscularis was invaded, and

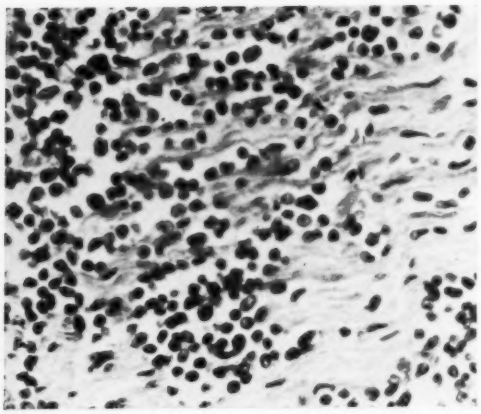

Fig. 2. Microscopic section from thickened wall of distended loop of ileum, showing infiltration of the muscular layer of the intestinal wall by lymphoid tissue.

the serosa involved (Fig. 2). The enlarged lymph nodes showed loss of their architecture and replacement by neoplasm, which in some areas had invaded through the capsule. The spleen similarly showed replacement of its normal tissue by tumor. In the kidneys, adrenals, and pancreas there were focal infiltrations of lymphoblastomatous tissue, with crowding and atrophy of parenchymatous structures. A similar but lesser degree of involvement of bone marrow, ureters, ovaries, fallopian tubes, and uterus was found.

The neoplastic tissue was essentially similar wherever seen. It appeared to be of essentially lymphoid nature and exhibited marked polymorphism. Many cells were hyperchromatic. Uninuclear and multinucleated giant cells were common, many being of the Sternberg or Dorothy Reed type. Plasma cells were frequent but eosinophils were scarce and there was little or no tendency to fibrosis. Moderate numbers of mitoses were found.

Summary of Autopsy Findings: Lymphoblastoma of Hodgkin's sarcoma type, involving mainly the small intestine, appendix, spleen, and abdominal pelvic lymph nodes, with lesser involvement of the kidneys, adrenals, pancreas, bone marrow, ureters, uterus, fallopian tubes, and ovaries.

EDITORIAL

Howard P. Doub, M.D., Editor

John D. Camp, M.D., Associate Editor

Fluoroscopy and Leukemia

"That the practice of radiology entails certain hazards to health and life was forcibly impressed on its practitioners many years ago, but not until a large number of radiologists had suffered or died from radiodermatitis and cancer. . . . It was soon learned that this danger could be averted by the ordinary precautions which are now habitually employed. So effective are these methods in the prevention of skin lesions that the radiologist has apparently been lulled into a false sense of security from all harm. His serenity is not due to ignorance, but to an unwarranted optimism in the face of his abundant knowledge. He is fully aware that intact skin may cover a multitude of internal changes wrought by irradiation. These changes are the expected result of radiotherapy; they are found at the necropsy table, are substantiated by experiments on animals, and are demonstrated conclusively by the microscope and the test tube."

These words of caution uttered by Carman twenty years ago were occasioned by his study of the case of a prominent radiologist who had died of lymphatic leukemia. There was reason to believe that lack of adequate protection during a large volume of fluoroscopic work might have contributed to the development of the disease in this instance.

Since the presentation of Carman's paper, numerous investigators have attempted to determine the role of roentgen rays in the production of leukemia by submitting animals—chiefly mice—to whole-body irradiation. These experiments have demonstrated a greatly enhanced incidence of the disease in the treated animals—from four to eight times that in unirradiated controls.

In this issue of RADIOLOGY Henshaw reports experiments in which mice were submitted to radiation of such intensity that damage could be produced in the blood-forming organs over a considerable period of time. The incidence of leukemia in these irradiated animals was almost 30 per cent, while in the control series it was only 7 per cent. There was a depression of the leukocyte count during the treatment period followed by a return to normal when irradiation was discontinued. In some animals the recovery extended into a leukocytosis, and in these leukemia invariably developed.

The results obtained from such experiments and the occasional occurrence of leukemia in those working with roentgen rays has prompted further studies to determine the role of radiation in the development of leukemia in man. In a recent study by Henshaw and Hawkins from the National Cancer Institute, the incidence of leukemia in physicians and in the general population was compared. It was found that leukemia was recognized approximately 1.7 times more frequently among physicians than among white males in the general population. This observation the writers point out does not necessarily indicate that radiation acted as the inciting agent. The significance of the findings lies in their accord with those demonstrated by animal experimentation.

An interesting study of leukemia in radiologists, by March, is presented in this issue of RADIOLOGY. He reports the death from leukemia of 8 American radiologists

during the past fifteen years, which would indicate that the incidence of the disease in radiologists is more than ten times as great as in other physicians during the same period. After calculating the probable error inherent in so small a series, March concludes that the observed increase is significant.

The danger of fluoroscopy to the operator has long been known and publicized, but too often attention has been given only to direct radiation, while the possibility of damage from secondary radiation has been neglected. The sources of stray radiation have been carefully studied by White, Cowie, and de Lorimier, and their conclusions deserve thoughtful consideration. They found a considerable escape of radiation from conventional "ray-proof" tubes and warn against over-confidence in such tubes, which usually require auxiliary protection. By far the greatest amount of secondary radiation, however, they attribute to the patient, and this is especially to be considered with the use of the horizontal fluoroscope. Built-in shields around such tables when combined with lead aprons give good protection. The area of the field also enters into consideration, as the secondary radiation from the patient is almost directly proportional to this factor.

Braestrup has also studied the matter of stray radiation in diagnostic radiology—particularly fluoroscopy—and has pointed to the need of a periodic check on the stray radiation received by the radiologic personnel. Of the three factors to be taken into consideration—equipment, structural shielding, and operating procedures—he considers the last by far the most important. Unless the roentgenologist gives his continued attention to this phase and has his staff do the same, it is not possible to secure satisfactory x-ray protection.

The possibility of administering a sizable dose of radiation to the patient must also be considered. Bell, who calculated this dose with various field sizes and target-skin distances, cautions that dosages may sometimes be administered to the gonadal tissue which may lead to hereditary changes in the offspring. The effect on the skin, especially when the examination is repeated and when in addition multiple films are made of the gastro-intestinal tract, may be considerable, and the amount of radiation received may approach an erythema dose.

It would appear trite to warn radiologists of the dangers of fluoroscopy but, when consideration is given to the effect on the skin, the germ cells, and the hematopoietic system, it is easily appreciated that the matter cannot be over-stressed. Too often we are guilty of neglect of the simplest rules of protection, thus directly endangering our own health and that of our associates. The period of fluoroscopic observation should be kept as short as possible consistent with obtaining the desired information. As a further check a fluoroscopic timer should be installed to guard both the radiologist and the patient. Gloves and an apron of proved ray-proof material should invariably be worn.

The papers cited above and many others attest to the interest which has been aroused among radiologists and biologists in possible injury to the blood stream and internal organs from the careless or overzealous use of radiation. It behooves us as radiologists to take the lead in applying the indicated safety measures.

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NEW ENGLAND ROENTGEN RAY SOCIETY

At the last annual meeting of the New England Roentgen Ray Society, the following officers were elected: President, Dr. Hugh F. Hare, Lahey Clinic, Boston, Mass.; Vice-President, Dr. Philip Batchelder, Providence, R. I.; Secretary-Treasurer, Dr. George Levene, Massachusetts Memorial Hospitals, Boston, Mass.

SECTION ON RADIOLOGY AMERICAN MEDICAL ASSOCIATION

At the annual meeting of the American Medical Association, the Section on Radiology elected the following officers: Chairman, Dr. Edwin C. Ernst, St. Louis; Secretary, Dr. U. V. Portmann, Cleveland; Representative to the American Board of Radiology, Dr. John W. Pierson, Baltimore; Delegate to the House of Delegates, Dr. B. R. Kirklin, Rochester, Minn.; Executive Committee, Dr. Edwin C. Ernst, Dr. Raymond C. Beeler, Indianapolis, and Dr. Robert A. Arens, Chicago.

ELECTION OF DR. E. U. CONDON TO THE NATIONAL ACADEMY OF SCIENCES

Dr. Edward U. Condon, Associate Director of the Research Laboratories for the Westinghouse Electric and Manufacturing Company, has been elected to membership in the National Academy of Sciences. Doctor Condon is especially known among radiologists for his interpretation of the phenomenon of spontaneous emission of alpha particles from such materials as radium, his theory being developed jointly with Dr. R. W. Gurney, formerly associated with him at Princeton University, now of the faculty of the University of Bristol, England. The deeper understanding of radioactivity provided by their studies paved the way of much of the more recent work in nuclear physics.

LOWELL S. GOIN, M.D. PRESIDENT, CALIFORNIA MEDICAL ASSOCIATION

Dr. Lowell S. Goin, of Los Angeles, Chairman of the Board of Directors of the Radiological Society of North America, has recently taken office as president of the California Medical Association. RADIOLOGY extends its congratulations to Doctor Goin and to the society that will benefit by the qualities of leadership which he brings to his new office.

Books Received

X-RAY EXAMINATION OF THE STOMACH. A DESCRIPTION OF THE ROENTGENOLOGIC ANATOMY, PHYSIOLOGY, AND PATHOLOGY OF THE ESOPHAGUS, STOMACH, AND DUODENUM. By FREDERIC E. TEMPLETON, M.D., Head of the Department of Roentgenology, The Cleveland Clinic. A volume of 516 pages, with 287 reproductions of x-ray plates. Published by the University of Chicago Press, Chicago, Ill. Price $10.00.

Book Review

UROLOGICAL SURGERY. By AUSTIN INGRAM DODSON, M.D., F.A.C.S., Richmond, Virginia, Professor of Urology, Medical College of Virginia; Urologist to the Hospital Division, Medical College of Virginia; Urologist to Crippled Children's Hospital; Urologist to St. Elizabeth's Hospital; Urologist to St. Luke's Hospital and McGuire Clinic. With Contributions by R. A. BERGER, M.D., F.A.C.R.; DOUGLAS G. CHAPMAN, M.D., F.A.C.P.; EVERETT IDRIS EVANS, Ph.D., M.D.; FRED M. HODGES, M.D., F.A.C.R., MAJOR GUY WINSTON HORSLEY; LINWOOD D. KEYSER, M.D., F.A.C.S.; LAWRENCE O. SNEAD, M.D., F.A.C.R. A volume of 768 pages, with 576 illustrations. Published by the C. V. Mosby Company, St. Louis. Price $10.00.

The author states in his preface that this book is intended as a "surgical supplement to the excellent books on the principles and practice of urology now in use." It is based on his own wide experience, but he has given much space to the experience of others, as reported in the literature.

He has divided his subject anatomically and treats methodically of the surgical treatment of the kidneys, ureters, bladder, urethra in both sexes, and the male external genitalia. Particular attention is given to the subject of plastic surgery of hydronephrosis, nephroptosis, and urethral anomalies. The book is well illustrated.

A rather unusual feature is the inclusion of chapters by contributing authors on excretory urography, radiation therapy, anesthesia, blood transfusion, endocrinology, and a long one on acid base balance and fluid administration. Dr. Lawrence O. Snead contributes the chapter on Urography and Cystography and Dr. Fred M. Hodges that on Radiation Therapy.

This is a valuable book for the surgeon, for whom, of course, it is designed. The radiologist will find it of less specific value.

IN MEMORIAM

JOHN T. MURPHY, M.D.

Aug. 15, 1885–June 15,1944

The *Toledo Times* of June 16, 1944, carried as the caption to its leading editorial "The World Has Lost a Great Physician" and stated in the closing sentence: "His life represents a great and permanent stride in the march of medicine toward its goal—to heal and comfort the sick."

The hundreds of personal friends and thousands of acquaintances of John Thomas Murphy will agree with these and many other tributes carried in that editorial. Murphy, in Radiology, was a national and international figure. And yet, the home town knew him best. At the end of life's span no tribute can quite compare with the simple expression of appreciation from the folks at home.

In and out of medicine John Murphy was known as a keen, progressive, professional gentleman, as a true physician, and as a brilliant and witty Irishman, upholding the best traditions of the Irish-American. To most of his friends and acquaintances he was either John or Murphy. The warmth of his personality was such that it could not be otherwise. His cordiality helped many a young man over the rough spots of the early years. In Radiology, a reference to, simply, "Murphy" left no confusion or uncertainty—"Where McTavish sits, there is the head of the table."

Murphy has completed a successful life: the success has been due largely to hard work, an unusually deep interest in people and a magnificent loyalty in friendships.

Doctor Murphy was graduated from the Medical College of the University of Toledo in 1906 and followed this with a varied postgraduate training in which pathology played an important part. This early interest carried through to be a factor of influence in some of the best work of his later years. From 1917 until the time of his death he was Director of the Department of Radiology of St. Vincent's Hospital, Toledo, as well as Consultant to other local hospitals.

A review of his writings is of interest in that it shows a trend from diagnostic subjects to therapy. His greatest contribution—the diagnosis of bone tumors—was stimulated by therapeutic experiences. This work on bone-tumor diagnosis calls for special mention because of its basic and fundamental importance, even though it is already widely known by reason of several national awards and many popular presentations in teaching courses before the various societies. But while the list of his contributions to the literature is substantial, it is in no way comparable to his direct contribution of personality in teaching.

Doctor Murphy was a member of all of the national radiological societies and had been honored by most of them. He was a Diplomate of the American Board of Radiology from its initial session in 1934. He was Secretary of the Section on Radiology of the A. M. A. from its establishment in 1931 until his death. He was Secretary of the American Roentgen Ray Society in 1928–31 and its President in 1934. He was President of the American College of Radiology in 1935.

Those who knew John Murphy best realized the effort necessary to the carrying on of so many public spirited enterprises within the field of Radiology in addition to the management of a large hospital service and a very active private practice. He never complained of his painful physical disabilities. Hard work in his extra-professional life seemed to balance his professional load. As a young man he excelled in track work and figure skating and was an outstanding amateur photographer. He devoted much time to flying when the airplane was still a "crate." When flying became safe and commonplace, he grounded himself and later became one of the leading figures in the establishment of Toledo's Civil Aeronautics Reserve Corps. His figure skating and fast motor-boating he carried on with to the last.

Doctor Murphy's interest in the problems of general betterment in society led to an active support of the Public Forum in Toledo, an organization which attracted outstanding talent to its platform for years.

This very full life has been terminated at the time of its maximum productivity. It will carry on with us, however, as a permanent monument of inspiration. Radiology pays tribute to a great physician, a loyal friend, and a grand Irishman.

DOUGLAS QUICK, M.D.

JOHN THOMAS MURPHY, M.D.
1885–1944

RADIOLOGICAL SOCIETIES OF NORTH AMERICA

Editor's Note.—Will secretaries of societies please cooperate by sending information to Howard P. Doub, M.D., Editor, Henry Ford Hospital, Detroit 2, Mich.

UNITED STATES

Radiological Society of North America.—Secretary, D. S. Childs, M.D., 607 Medical Arts Building, Syracuse 2, N. Y.

American Roentgen Ray Society.—Secretary, Harold Dabney Kerr, M.D., Iowa City, Iowa.

American College of Radiology.—Secretary, Mac F. Cahal, 540 N. Michigan Ave., Chicago 11, Ill.

Section on Radiology, American Medical Association.—Secretary, U. V. Portmann, M.D., Cleveland Clinic, Cleveland 6, Ohio.

ARKANSAS

Arkansas Radiological Society.—Secretary, J. S. Wilson M.D., Monticello. Meets every three months and annually at meeting of State Medical Society.

CALIFORNIA

California Medical Association, Section on Radiology.—Secretary, Earl R. Miller, M.D., University of California Hospital, San Francisco, Calif.

Los Angeles County Medical Association, Radiological Section.—Secretary, Roy W. Johnson, M.D., 1407 South Hope St., Los Angeles. Meets second Wednesday of each month at County Society Building.

Pacific Roentgen Society.—Secretary, L. Henry Garland, M.D., 450 Sutter St., San Francisco. Meets annually during meeting of California Medical Association.

San Diego Roentgen Society.—Secretary, Henry L. Jaffe, M.D., Naval Hospital, Balboa Park, Calif. Meets first Wednesday of each month.

San Francisco Radiological Society.—Secretary, Martha Mottram, M.D., Suite 1789, 450 Sutter St., San Francisco. Meets monthly on third Thursday at 7:45 P.M., in Toland Hall, University of California Hospital, from January to June; at Lane Hall, Stanford University Hospital, July to December.

COLORADO

Denver Radiological Club.—Secretary, A. Page Jackson, Jr., M.D., 304 Republic Bldg., Denver 2. Meetings third Friday of each month at the Denver Athletic Club.

CONNECTICUT

Connecticut State Medical Society, Section on Radiology.—Secretary, Max Climan, M.D., 242 Trumbull St., Hartford 3. Meetings bimonthly, second Thursday.

FLORIDA

Florida Radiological Society.—Secretary-Treasurer, Charles M. Gray, 306 Citizens Bldg., Tampa 2.

GEORGIA

Georgia Radiological Society.—Secretary-Treasurer, James J. Clark, M.D., 478 Peachtree St., N. E., Atlanta 3. Meetings twice annually, in November and at the annual meeting of State Medical Association.

ILLINOIS

Chicago Roentgen Society.—Secretary, Warren W. Furey, M.D., 7144 Jeffery Ave., Chicago 49. Meets at the Palmer House, second Thursday of October, November, January, February, March, and April.

Illinois Radiological Society.—Secretary-Treasurer, William DeHollander, M.D., St. Johns' Hospital, Springfield. Meetings quarterly by announcement.

Illinois State Medical Society, Section on Radiology.—Secretary, Fay H. Squire, M.D., 1753 W. Congress St., Chicago 12.

INDIANA

The Indiana Roentgen Society.—Secretary-Treasurer, Harold C. Ochsner, M.D., Methodist Hospital, Indianapolis 7. Annual meeting in May.

IOWA

The Iowa X-ray Club.—Holds luncheon and business meeting during annual session of Iowa State Medical Society.

KENTUCKY

Kentucky Radiological Society.—Secretary-Treasurer, Sydney E. Johnson, M.D., Louisville City Hospital, Louisville. Meeting annually in Louisville, third Saturday afternoon in April.

LOUISIANA

Louisiana Radiological Society.—Secretary-Treasurer, Johnson R. Anderson, M.D., North Louisiana Sanitarium, Shreveport. Meets annually at same time as State Medical Society.

Shreveport Radiological Club.—Secretary-Treasurer, R. W. Cooper, 940 Margaret Place. Meetings monthly on the second Wednesday, at the offices of the various members.

MARYLAND

Baltimore City Medical Society, Radiological Section.—Secretary, Walter L. Kilby, M.D., 101 W. Read St., Baltimore 1. Meets third Tuesday of each month.

MICHIGAN

Detroit X-ray and Radium Society.—Secretary-Treasurer, E. R. Witwer, M.D., Harper Hospital, Detroit 1. Meetings first Thursday of each month from October to May, inclusive, at Wayne County Medical Society club rooms, 4421 Woodward Ave., Detroit.

Michigan Association of Roentgenologists.—Secretary-Treasurer, E. M. Shebesta, M.D., 1429 David Whitney Bldg., Detroit. Meetings quarterly by announcement.

MINNESOTA

Minnesota Radiological Society.—Secretary, A. J. Stenstrom, M.D., Minneapolis General Hospital, Minneapolis 26. Meetings quarterly.

MISSOURI

Radiological Society of Greater Kansas City.—Secretary, Arthur B. Smith, M.D., 306 E. 12th St., Kansas City, Mo. Meetings last Thursday of each month.

The St. Louis Society of Radiologists.—Secretary, E. W. Spinzig, M.D., 2646 Potomac St. Meets on fourth Wednesday of each month except June, July, August, and September, at a place designated by the president.

NEBRASKA

Nebraska Radiological Society.—Secretary, F. L. Simonds, M.D., 1216 Medical Arts Bldg., Omaha 2. Meetings third Wednesday of each month at 6 P.M. in either Omaha or Lincoln.

NEW ENGLAND

New England Roentgen Ray Society (Maine, New Hampshire, Vermont, Massachusetts, and Rhode Island).—*Secretary-Treasurer,* George Levene, M.D., Massachusetts Memorial Hospitals, Boston, Mass. Meets monthly on third Friday at Boston Medical Library.

NEW JERSEY

Radiological Society of New Jersey.—Secretary, H. J. Perlberg, M.D., Trust Co. of New Jersey Bldg., Jersey City. Meetings at Atlantic City at time of State Medical Society and midwinter in Newark as called by president.

NEW YORK

Associated Radiologists of New York, Inc.,—Secretary, William J. Francis, M.D., 210 Fifth Ave., New York City. Regular meetings the first Monday evening of the month in March, May, October, and December.

Brooklyn Roentgen Ray Society.—Secretary-Treasurer, Leo Harrington, M.D., 880 Ocean Ave., Brooklyn 26. Meets fourth Tuesday of every month, October to April.

Buffalo Radiological Society.—Secretary-Treasurer, Joseph S. Gianfranceschi, M.D., 610 Niagara St., Buffalo 1. Meetings second Monday evening each month. October to May, inclusive.

Central New York Roentgen Ray Society.—Secretary-Treasurer, Carlton F. Potter, M.D., 425 Waverly Ave., Syracuse 10. Meetings are held in January, May, and October, as called by Executive Committee.

Long Island Radiological Society.—Secretary, Marcus Wiener, M.D., 1430 48th St., Brooklyn 19. Meetings fourth Thursday evening each month at Kings County Medical Bldg.

New York Roentgen Society.—Secretary, Ramsay Spillman, M.D., 115 E. 61st St., New York 21, N. Y.

Rochester Roentgen-ray Society.—Secretary, Murray P. George, M.D., 260 Crittenden Blvd., Rochester 7. Meetings at convenience of committee.

NORTH CAROLINA

Radiological Society of North Carolina.—Secretary-Treasurer, Major I. Fleming, M.D., 404 Falls Road, Rocky Mount. Meeting with State meeting in May, and meeting in October.

NORTH DAKOTA

North Dakota Radiological Society.—Secretary, L. A. Nash, M.D., St. John's Hospital, Fargo. Meetings by announcement.

OHIO

Ohio Radiological Society.—Secretary, J. E. McCarthy, M.D., 707 Race St., Cincinnati 2. Next meeting will be held at the time and place of the annual meeting of the Ohio State Medical Association.

Cleveland Radiological Society.—Secretary-Treasurer, Don D. Brannan, M.D., 11311 Shaker Blvd., Cleveland 4. Meetings at 6:30 P.M. on fourth Monday of each month from October to April, inclusive.

Radiological Society of the Academy of Medicine (Cincinnati Roentgenologists).—*Secretary-Treasurer,* Samuel Brown, M.D., 707 Race St., Cincinnati 2. Meetings held third Tuesday of each month.

PENNSYLVANIA

Pennsylvania Radiological Society.—Secretary-Treasurer, L. E. Wurster, M.D., 416 Pine St., Williamsport 8. The Society meets annually.

The Philadelphia Roentgen Ray Society.—Secretary, Robert P. Barden, M.D., 3400 Spruce St., Philadelphia 4. Meetings held first Thursday of each month at 8:15 P.M., from October to May, in Thomson Hall, College of Physicians, 21 S. 22nd St., Philadelphia.

The Pittsburgh Roentgen Society.—Secretary-Treasurer, Reuben G. Alley, M.D., 4800 Friendship Ave., Pittsburgh 24, Pa. Meetings are held on the second Wednesday of each month at 4:30 P.M., from October to June, at the Pittsburgh Academy of Medicine, 322 N. Craig St.

ROCKY MOUNTAIN STATES

Rocky Mountain Radiological Society (North Dakota, South Dakota, Nebraska, Kansas, Texas, Wyoming, Montana, Colorado, Idaho, Utah, New Mexico).—*Secretary,* A. M. Popma, M.D., 220 North First St. Boise, Idaho.

SOUTH CAROLINA

South Carolina X-ray Society.—Secretary-Treasurer, Robert B. Taft, M.D., 103 Rutledge Ave., Charleston 16. Meeting in Charleston on first Thursday in November, also at time and place of South Carolina State Medical Association.

TENNESSEE

Memphis Roentgen Club.—Chairmanship rotates monthly in alphabetical order. Meetings second Tuesday of each month at University Center.

Tennessee Radiological Society.—Secretary-Treasurer, J. Marsh Frère, M.D., 707 Walnut St., Chattanooga. Meeting annually with State Medical Society in April.

TEXAS

Texas Radiological Society.—Secretary-Treasurer, Herman Klapproth M.D., Sherman.

VIRGINIA

Virginia Radiological Society.—Secretary, E. Latané Flanagan, M.D., 215 Medical Arts Bldg., Richmond 19.

WASHINGTON

Washington State Radiological Society.—Secretary-Treasurer, Thomas Carlile, M.D., 1115 Terry Ave., Seattle. Meetings fourth Monday of each month, October through May, at College Club, Seattle.

WISCONSIN

Milwaukee Roentgen Ray Society.—Secretary-Treasurer, C. A. H. Fortier, M.D., 231 W. Wisconsin Ave., Milwaukee 3. Meets monthly on second Monday at the University Club.

Radiological Section of the Wisconsin State Medical Society.—Secretary, Russell F. Wilson, M.D., Beloit Municipal Hospital, Beloit. Two-day annual meeting in May and one day in connection with annual meeting of State Medical Society, in September.

University of Wisconsin Radiological Conference.—Secretary, E. A. Pohle, M.D., 1300 University Ave., Madison 6, Wis. Meets every Thursday from 4 to 5 P.M., Room 301, Service Memorial Institute.

CANADA

La Société Canadienne-Française d'Electrologie et de Radiologie Médicales.—General Secretary, Origène Dufresne, M.D., Institut du Radium, Montreal. Meetings are held the third Saturday of each month, generally at the Radium Institute, 4120 East Ontario Street, Montreal; sometimes, at homes of members.

CUBA

Sociedad de Radiología y Fisioterapia de Cuba.—Offices in Hospital Mercedes, Havana. Meetings are held monthly.

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ROENTGEN DIAGNOSIS

THE HEAD AND NECK

Aero-Otitis Media: A Roentgenologic Study. J. C. Larkin. Am J. Roentgenol. **51:** 178–185, February 1944.

Aero-otitis media is the name applied to a condition which may develop when the air pressure in the tympanic cavity is not equal to the pressure in the external auditory meatus and posterior nasal pharynx. This inequality of pressure results in a collapse of the tympanic membrane against the labyrinthic wall of the internal ear and a shift of the auditory ossicles. This usually is followed by congestion and inflammation of these structures and there may be hemorrhage into the tympanic membrane. Hearing may be lost for a few hours or even days. The condition is rather common among the hundreds of thousands now engaged in aviation.

For roentgen examination of the structures involved, the author recommends a modified vertico-submental view, similar to that used for examination of the sphenoidal sinus. If lipiodol is injected into the external canal, the anatomic outlines of this structure can be recognized and thus the position of the tympanic membrane can be distinguished. It has been found that the ossicles of the ear lie above and lateral to the central portion of the tympanic membrane. These structures are not always demonstrable on roentgenograms, however, so that their presence or absence is of no clinical value, and it is only when the right and left sides can be compared that the examination yields useful information. Shifting in position of the ossicles indicates a shifting of the tympanic membrane, although this has not been found to be an absolute criterion for aero-otitis media. However, blurring of the shadows of the ossicles due to congestion and the accumulation of exudate in the tympanic cavity and surrounding air cells has shown a correlation with the clinical findings, and these roentgen changes can be relied upon to indicate aero-otitis media. L. W. PAUL, M.D.

THE CHEST

Pneumoconiosis: Story of Dusty Lungs. Lewis Gregory Cole. Am J. Roentgenol. **51:** 125–177, February 1944.

This article is an abstract of material which has been published elsewhere in book form. In it the author presents the results of his researches on pneumoconiosis. A good deal of the discussion is given over to the pathologic aspects of this condition and in this respect some of the author's observations are at variance with the published reports of others. Thus, his observations indicate that the dense areas in the lungs which cause roentgen shadows in cases of pneumoconiosis are not due to connective tissue but are caused by dust, dust-laden phagocytes, and collagen, either in the alveoli or in the pulmonary stroma. This finding is of some interest, since in chronic inflammatory and tuberculous lesions of long standing, connective tissue develops which contracts and deforms the thoracic cage, whereas massive accumulations of collagen, no matter how old, do not do this.

On the basis of roentgenologic and pathologic findings, six separate types of pneumoconiosis can be recognized.

(*1*) *Peribronchial Perivascular Pneumoconiosis:* This term was first applied by Pancoast, but later workers have looked upon it with disfavor. The author believes, however, that Pancoast was correct and that there is such a type of silicosis which can be recognized. In this lesion the inhaled dust lodging in the alveoli is engulfed by phagocytes and carried through the lymph channels paralleling the blood vessels and bronchi, either toward the hilum or toward the pleura. Some of these phagocytes become blocked in the lymph channels at the hilum, and others are dammed back into the lymph channels paralleling the larger and medium-sized bronchi. This causes deposition of collagen in laminae around the larger and medium-sized blood vessels and bronchi. The roentgen findings consist in increased density of the lungs, usually bilateral, relatively symmetrical, and often accompanied by increased opacity at both bases and perhaps at both apices. The hilum shadows are increased and may be circumscribed or may radiate out along the blood vessels and bronchi.

(*2*) *Vesicular Pneumoconiosis:* In this type the dust-laden phagocytes and small strands of collagen are laid down in the lymph channels surrounding the smaller blood vessels, bronchioles, and terminal lung lobules. The roentgen findings are evidenced by a bilateral, relatively symmetrical diffuse mottling with a pattern not so clear cut and well defined as a silicotic nodule. These roentgen findings are by no means new. They have been described as fine nodulation, ground-glass appearance, anteprimary, etc.

(*3*) *Nodular Pneumoconiosis:* In this form, roentgenograms show a bilateral symmetrical nodulation in which the nodules are sharp and clear-cut with no relationship to the blood vessels and bronchi. These nodules are composed of collagen laid down like the layers of an onion, and adult nodules contain very little dust. This type of lesion is slow in developing and patients are often free of symptoms even when the lungs are filled with nodular foci.

(*4*) *Chronic tuberculoid pneumoconiosis* looks like tuberculosis but is not caused by the tubercle bacillus. The dust-laden phagocytes congregate in an alveolus or in adjacent alveoli and together with collagen form small, irregularly spherical masses that correspond in size and shape to the pulmonary tubercles of acid-fast bacillus origin. The roentgen findings may simulate tuberculosis very closely. The lesion is usually bilateral, by no means symmetrical, and often there are large dense areas in one or the other apex and infiltration of various-sized nodules in the opposite mid-lung field.

(*5*) *Cystic Pneumoconiosis:* In this form the bronchioles leading to the terminal lung lobules become occluded by masses of collagen or dust-laden phagocytes. This causes a valve-like action which allows air to enter the terminal lung lobule but does not allow its exit, resulting in an air cyst. In the roentgenograms this produces ring-like shadows encircling darker areas, the direct antithesis of the nodular type, which is manifest roentgenographically by white spots on a dark background. These lesions are bilateral; often they are not as symmetrical as the first three types, and the cystic appearance predominates.

(*6*) *Parenchymal pneumoconiosis (acute silicosis)*

includes (*a*) acute pneumonic parenchymal and (*b*) acute tuberculoid pneumoconiosis. In the first form the roentgen findings are a diffuse generalized haze or cloudiness involving both lung fields, usually bilateral but not symmetrical. There may be localized patches of increased density that suggest more advanced degrees of consolidation. Distinct nodulation is usually absent. Acute tuberculoid pneumoconiosis simulates acute miliary tuberculosis. The social and economic problems of this form of the disease are especially serious, because of their rapid development and because the lesion may not be recognized as silicosis.

L. W. PAUL, M.D.

Radiological Appearances in the Development of Coal Miners' Pneumokoniosis. E. A. Aslett, T. W. Davies, and T. I. Jenkins. Brit. J. Radiol. **16:** 308–313, October 1943.

Thirty-one coal miners who were known to have silicosis were re-examined after three and a half to four and a half years. Comparison of the films shows that simple nodulations may become coalescent. In advanced cases a streaky fibrosis occurs which may be a factor in the development of emphysema. This fibrosis also aids in drawing the nodules together to form increasingly dense lesions.

Tomographic studies, made in 4 cases, indicate that the disease may be more extensive than is apparent in plain films.

SYDNEY J. HAWLEY, M.D.

Radiologic Evidence in Haematite Iron-Ore Workers. Richard Fawcitt. Brit. J. Radiol. **16:** 323–330. November 1943.

Hematite itself is opaque to x-rays and its presence in the lungs may result in a fine flake-like mottling. Some hematite miners, especially those working in dry mines and those which have a high silica content, show a progressive fibrosis indistinguishable from silicosis.

SYDNEY J. HAWLEY, M.D.

Occupational Disease of the Lungs in Boiler Scalers. Lasar Dunner. Brit. J. Radiol. **16:** 287–290, October 1943.

Boiler scalers may show a nodular infiltration in the lungs similar in appearance to miliary tuberculosis and silicosis. The clinical symptoms and physical findings are not characteristic. The diagnosis depends upon the roentgen picture and the occupational history.

SYDNEY J. HAWLEY, M.D.

Atypical Pneumonia of Unknown Etiology: A Clinical, Roentgenological, and Pathological Correlation. Frank B. Lusk and E. Kenneth Lewis. Dis. of Chest **10:** 19–40, January–February 1944.

Five hundred patients representing a cross section of some 6,000 cases of acute epidemic respiratory tract infection seen in the Station Hospital at Fort Custer, Michigan, from Dec. 1, 1942, to June 1, 1943, constitute the basis of this paper. In 60 per cent of these the infection cleared without pulmonary involvement; in 15 per cent a diagnosis of bronchitis was made; in 25 per cent there were roentgen evidences of pneumonia.

The authors are of the opinion that atypical pneumonia is not a clinical entity *per se*, but one phase of a generalized disease. From the clinical and roentgen evidences they divide the generalized infection into four stages: bronchitic, peribronchitic, alveolar, and broncho-alveolar. Of these, all but the first present more or less characteristic roentgen findings. The peribronchitic stage shows "increased size of the hilar shadows" and "increased density of the trunkal markings radiating as shafts toward the diaphragm." The alveolar stage is represented roentgenographically by "(*a*) the small irregular, slightly opaque shadow or shadows lurking among the thickened bronchi; (*b*) that well-circumscribed or ill-defined shadow, soft, fleecy, ground-glass in appearance, which spreads out fan-like from the hilus, or which hangs unsuspended here and there throughout the lung fields; (*c*) that extensive lesion which, occupying the greater part of a lobe, reaches out toward the periphery or the interlobar pleurae." In the broncho-alveolar stage the appearance is one of "diffuse mottling" or "small, denser, tapioca-like granules, confined to the bases, adjacent to the increased trunkal markings or scattered throughout the parenchyma."

Five photomicrographs are included from a fatal case of recurrent atypical pneumonia complicated by an acute nephritis plus a superimposed bacterial pneumonia.

An attempt is made to correlate the clinical, roentgenological, and pathological findings.

HENRY K. TAYLOR, M.D.

Benign Nontuberculous Bronchial Stenosis. Herbert W. Schmidt. Arch. Otolaryng. **39:** 43–52, January 1944.

Benign non-tuberculous bronchial stenosis is a rather common complication of infections of the respiratory tract but it is rarely recognized. There is usually a history of antecedent pneumonia, severe tracheobronchitis, or repeated seizures of asthmatic bronchitis. After variable periods, recurrent bouts of chills, fever, and general malaise develop. The period of fever is usually preceded by an irritating, non-productive cough. The temperature may reach 102–103° F. and persist for two to seven days, at the end of which time a purulent secretion is coughed up. This relieves the symptoms.

The lower lobe of the right lung is more likely to be the site of a benign non-tuberculous bronchial stenosis than the upper or middle lobes. Physical findings may be absent, since the stenosis usually involves the third division of a bronchus. When present, they are usually those of obstructive atelectasis, namely, dullness on percussion and decrease in breath sounds over that portion of the lung supplied by the involved bronchus.

Roentgen examination is important in determining the presence of atelectasis, but does not always indicate whether or not a bronchus leading to the affected region is open or closed. In obstructive atelectasis, the pulmonary field is reduced; the heart and mediastinum are displaced toward the affected side; there may be narrowing of the intercostal spaces with increased downward inclination of the ribs; the diaphragm is elevated and shows decreased motion on the side of the lesion. The atelectatic region itself will show increased density.

In cases of valvular obstruction with emphysema the roentgenograms show increased transparency of the involved side. The diaphragm is depressed and partially fixed. The mediastinal structures are displaced from the affected side. There is increased movement of the diaphragm on the opposite side.

Bronchography may help in determining the site of an obstruction, if one exists.

Bronchoscopy is the only clinical method of diagnosing a benign bronchial stenosis and is the only satisfactory way of treating such a lesion, dilatation producing favorable results in about 66 per cent of cases. It should not be carried out, however, for two or three weeks after an acute attack in suspected cases. If the patient is suffering from chronic asthmatic bronchitis, the bronchial mucosa is inflamed and variable amounts of secretion—mucoid, mucofibrinous, or mucopurulent—are present on both sides. The stenotic bronchus is almost always a branch of one of the bronchi supplying the lower lobe. The mucous membrane around the orifice is inflamed and edematous. The normal diameter of the orifice may be reduced to a sixth or a fourth, or the bronchus may be completely closed, and there is no change in size with inspiration and expiration. Usually there is a trickle of purulent secretion coming from its orifice. If the bronchus is dilated, bloody mucopurulent material comes from its depths. The bronchus bleeds more readily when touched than a normal bronchus. At times it is difficult to be certain that the lesion is not a cancer and a biopsy is advisable.

The findings in 25 cases of benign non-tuberculous bronchial stenosis are reviewed, and 4 cases of particular interest are reported in detail.

Right-Sided Aortic Arch. Report of a Case. Harold J. Isard. U. S. Nav. M. Bull. **42:** 168–171, January 1944.

The author reports a case of right-sided aortic arch. This finding was purely coincidental and was established by fluoroscopy, at which time the trachea and esophagus appeared deviated to the left and anteriorly, while the aortic knob was present to the right of the mid-line. ELLWOOD W. GODFREY, M.D.

THE DIGESTIVE SYSTEM

Kymography and Its Application to Œsophageal Movement. John W. McLaren. Brit. J. Radiol. **16:** 270–273, September 1943.

Kymographic studies of the esophagus with the aid of a thick paste of barium were made. By enlarging the tracings and reconstructing the movements of the whole esophagus from these enlargements, it is shown that there is a regular constricting wave which passes down the esophagus after swallowing. There is no evidence that this is preceded by a zone of relaxation. Liquids appear to fall rapidly down the tube.

SYDNEY J. HAWLEY, M.D.

Peptic Ulceration of the Esophagus with Partial Thoracic Stomach. A. S. Johnstone. Brit. J. Radiol. **16:** 357–361, December 1943.

A study of 7 cases shows that peptic ulceration occurs chiefly in older patients and in patients with congenitally short esophagi or hiatal herniae. Hiatal herniae are more frequent in older people.

Frequent regurgitation of acid gastric contents is probably the precipitating cause of ulceration when the anatomical defects are present. When the ulcers are chronic, scar tissue develops which, when it contracts, may increase the hiatal hernia or the shortness of the esophagus, setting up a vicious cycle.

In an addendum the author refers to the "original article," written in collaboration with Allison and Royce (Allison, P. R., Johnstone, A. S., and Royce, G. B.; J. Thoracic Surg **12:** 432, 1943. Abst. in Radiology **42:** 94, 1944), reporting 10 cases (including the 7 mentioned above) of short esophagus with peptic ulceration. Eleven additional cases have now been seen.

SYDNEY J. HAWLEY, M.D.

Malignant Tumors of the Stomach. Felix de Amesti. Am. J. Surg. **63:** 78–85, January 1944.

Of 127 patients with malignant gastric tumors admitted to Surgical Section "B" of the Hospital del Salvador, Santiago, Chile, from 1938 to 1942, 104 were subjected to operation. Sixteen patients refused operation; 7 were considered inoperable. In 98.55 per cent of the cases the tumor was found on histologic examination to be a carcinoma; in 1.44 per cent, a lymphosarcoma. Seventy-four per cent of the series were males. In the female, the greatest frequency of carcinoma was in the fourth and fifth decades; in the male, in the fifth and sixth decades. In over half of the cases, dyspepsia was the predominant symptom at the onset of the illness; when admitted to the hospital, however, the patient usually had a combination of symptoms. It was found that when the evolution of symptoms had covered more than a year the rate of operability was higher than in cases with a shorter history, probably due to the fact that in those with the longer history the neoplasm was of a less malignant character.

Roentgen examinations were done in 116 cases; gastric cancer was diagnosed in 109 of these. In 4 patients the diagnosis was not made at first but was established at a second examination following a gastroscopic diagnosis of cancer. Two patients were thought to have gastric ulcers; one, a degenerated gastric ulcer; two, pyloric stenosis; one, a benign gastric tumor; and one, an organic pyloric lesion.

Gastroscopy was performed on 49 patients, and led to a diagnosis of cancer in 46. In 37 cases a diagnosis of associated atrophic gastritis was made and this was confirmed by histologic examination.

The lesion was located on the lesser curvature of the stomach in 29.75 per cent of the cases; in the antropyloric region in 29 per cent; in the cardiac end in 8.26 per cent; in the pylorus exclusively in 4.13 per cent; on the greater curvature in 1.65 per cent; and in the corpus in 2.47 per cent.

Forty-nine of the 104 patients operated upon had subtotal gastrectomies; 9, total gastrectomies. The operative resectability was therefore 56 per cent; the postoperative mortality in this group was 21 per cent.

The author presents survival statistics, but unfortunately only 36.43 per cent of the patients had been followed, and none for as long as five years. One patient who had a subtotal gastrectomy had survived for more than four years; 13 were alive from one month to two years following operation. One of the patients who had a total gastrectomy was alive and in good condition fourteen months after the operation.

Radiographic Findings in Idiopathic Steatorrhœa. J. F. Brailsford. Brit. J. Radiol. **16:** 283–285, September 1943.

For radiologic study of the small intestine in idiopathic steatorrhea, it is essential to take a series of

roentgenograms in the prone position, commencing immediately after ingestion of the barium suspension. With a watery suspension, the barium may not begin to pass immediately, but usually within fifteen minutes the greater portion of the jejunum can be demonstrated. This will present a normal appearance (uniform caliber; well defined, regular, smooth mucosal folds; a continuous column of barium) during the first thirty minutes. Thereafter the barium appears broken up into small curds or clumps. There is apt to be considerable hypermotility, the barium reaching the rectum before the stomach is empty.

The calcium metabolism is seriously disturbed in cases of idiopathic steatorrhea and this is reflected in the appearance of the bones. Radiographically these reveal a lack of compact cortex, though the outlines are sharp. The main trabeculae are parallel to the long axis of the bones and appear less closely packed together than normal. The metaphyses are greater in depth than normal and the outline of the diaphyses is blurred. The long bones tend to bend. The vertebral bodies show biconcave compression. The skull in the adolescent shows a fine stippled osteoporosis, while at a later age general decalcification may be associated with multiple ill-defined islands of varying size and density.

SYDNEY J. HAWLEY, M.D.

Diverticulitis of the Colon: Review of the Literature and an Analysis of Ninety-One Cases. Edward L. Young and Edward L. Young, III. New England J. Med. **230:** 33–38, Jan. 13, 1944.

The incidence of diverticulosis of the colon is estimated at between 3 and 10 per cent. It is stated that 12 to 15 per cent of the cases progress to diverticulitis and that in about 15 per cent of patients with diverticulitis complications necessitate operation.

There are two types of diverticula: the congenital type, in which all the layers of the bowel wall are included, and the acquired type, which is a herniation of the mucosa through the muscular coat. The acquired type seems to be of mechanical origin, due to pressure in a bowel that is undergoing fatty degeneration of the muscle and loss of elasticity.

Diverticulitis is a disease of adult life; 95 per cent of the patients are beyond forty years of age, the highest incidence being in the fifth and sixth decades. It results from obstruction of the diverticular ostium, with edema and inflammation, which may progress to acute perforation of the bowel or develop into a pericolitis. Either process may go on to a general peritonitis.

The symptomatology of diverticulosis is not characteristic. The classical picture of diverticulitis includes pain in the left lower quadrant, low-grade fever, slight leukocytosis, flatulence, some nausea, and irregular bowel habits, but not all of these symptoms need be present. As complications develop, the symptomatology becomes consistent with each. Thus, a sudden acute pain in the abdomen suggests acute perforation with peritonitis; a mass in the left lower quadrant indicates an indurated, thickened sigmoid or a localized abscess; obstipation may mean inflammatory and fibrotic closure of the sigmoid; sudden disappearance of a mass, relief of pain, and the appearance of pus from the urethra or rectum suggest perforation of an abscess with formation of a fistula.

Diagnosis is based on the history, physical examination, proctoscopy, and a barium enema study, the last being the most valuable and accurate procedure. Diverticulitis is manifested by spasm, hypermotility of varying degrees, and occasionally by tenderness.

Treatment consists in establishing good bowel habits, with a low-roughage diet and mineral oil but no irritating cathartics. Rectal instillation of a dilute suspension of 30 gm. of x-ray barium in 90 c.c. of warm water, following a cleansing enema, twice weekly at first and later once a week, has given good results in the senior author's hands. Complications such as perforation and abscess formation must be handled surgically according to indications.

The authors report a series of 84 cases [not 91 as the title states] of diverticulitis of the sigmoid, of which 43 were chronic and 41 acute. In their observations they found the following facts of importance: Blood in the stool was found in 26 per cent of the cases where no other cause than the diverticulitis was found. The incidence of this condition was much higher in this series than in others, which suggests that in a true cross section of disease as seen by the general practitioner diverticulitis should be oftener recognized and treated. Conservative treatment, especially the use of x-ray barium either by mouth or, where possible, by rectum, gives a high percentage of relief. When surgery is needed, the simplest procedure possible is accompanied by the lowest mortality.

JOHN B. MCANENY, M.D.

THE SKELETAL SYSTEM

Solitary Eccentric (Cortical) Abscess in Bone. R. C. Brown and Ralph K. Ghormley. Surgery **14:** 541–553, October 1943.

Solitary cortical bone abscesses give rise to a rather definite syndrome, pursue a regular benign course, without complication, and are susceptible to complete surgical eradication. They occur in both the long and the short bones, being characteristically placed, lying within, subjacent to, or superposed on, the cortex, occasionally in the neighborhood of an articulating surface. The exciting center of the lesion itself is minute, not exceeding a few millimeters in diameter as seen both at operation and in the roentgenogram. It elicits a variable mass of reaction, dependent seemingly upon the location with respect to the cortex and little affected by the age of the lesion.

Twenty-four patients with abscesses of this type were seen in a period of ten years (up to 1941) at the Mayo Clinic. The majority were distributed equally among the first three decades of life, with three in the fourth and fifth decades. The tibia and femur were the most common sites, accounting for 20 of the 24 cases. The lesion was also seen in the fibula, the radius, the os calcis, and the patella.

The clinical picture is that of a relatively mild but troublesome condition. Pain is the outstanding symptom, with a strong tendency to wax and wane. Exacerbations occurred commonly in changes of weather or with unusual exertion. The patient's localization of the pain is in most instances accurate to a high degree. Sharp pain often occurs at night, particularly among children. Nocturnal pain is more common as the disease process continues. Swelling, the next most common symptom, is more in the nature of a thickening and induration accompanied by redness and increased heat. In the series reported a limp was present when the abscess involved an area about a joint, as in the neck

or lower part of the femur, in the superior third of the tibia, and particularly in the os calcis and patella.

The chronicity of the complaint is striking. One patient had had pain for thirty-five years, another for twenty-seven, and a third and fourth for ten and nine years, respectively.

Roentgenologically the minute exciting lesion is characteristically seen, radiolucent, located within or beneath the cortex, but most commonly in the osteoplastic reactive portion of the periosteum. The authors agree with others that the lesions do occur within and on either side of the cortex. Reaction with osteosclerosis occurs about the lesions uniformly and is the pathognomonic element of the picture, especially its eccentric position. Relatively enormous elevation of the periosteum is seen with heavy densification. A question as to the presence of a Ewing tumor is usually settled by the visibility of the minute radiolucent area apparently in the center, geometrically speaking, of the reactive portion.

The treatment of these patients was not uniform. Fourteen were operated upon and obtained definite relief. One was given roentgen therapy and was much improved a year later. Another showed improvement both clinically and roentgenographically after a period of bed rest. Surgical excision is the procedure of choice, offering the best assurance of relief.

In spite of the fact that there was measurable fever in only one of the cases of this series, inflammation is believed to be the basis of the lesion. Nine of the patients gave a history of trauma, as a bump, a fall, a puncture wound, etc. Eight patients had a previous focal infection, such as chronic cervicitis, tonsillitis, a boil, or typhoid fever. In 10 cases microscopic examination of tissue removed surgically showed chronic inflammation. The fact that many of the cases had persisted for years is opposed to a neoplastic origin. One gets the impression of a small lesion being overwhelmed by a massive defensive mechanism apparently present in the region of the bone cortex.

J. E. WHITELEATHER, M.D.

"Stress" or "Fatigue" Fractures of Bone. J. Blair Hartley. Brit. J. Radiol. **16:** 255–262, September 1943.

"Stress fractures," or "fatigue fractures," as the author prefers to call them, occur most frequently in the metatarsals, and after this, in order, in the tibia, femur, and fibula. They are rare in other bones. They are most common in adolescence and early manhood. Synonyms which have been used to designate fractures of this type are insufficiency fracture, overload fracture, wear-and-tear fracture, recruit's disease, periostitis ab exercitio, osteopathia itineraria, soldier's fracture, and pseudo-fracture. Actually, pseudo-fractures—Looser's "Umbauzonen"—constitute a distinct entity. They invariably occur in diseased bone and are accompanied by little or no callus, while stress fractures involve otherwise normal bone and show rapid and abundant callus formation.

The clinical features vary with the stage of the malady. Pain, particularly on weight-bearing, is the chief symptom. This is relieved by putting the part at rest. The chief radiological indication is callus formation, usually at the site of the torque or point of greatest stress. As a rule, a small crack or fracture line may be demonstrated.

The cause of these fractures has been said to be a nutritional deficiency or hypovitaminosis. While such a factor may be present, however, it can be shown that the fracture occurs at the point of greatest stress and is therefore probably mechanical in origin, even though there is no history of trauma. It is not true that stress fractures are always observed at the site of the nutrient foramina.

The treatment consists of rest for the affected bone. If the diagnosis is made early, a few weeks will suffice. If rest is not instituted, complete fracture may occur.

In the differential diagnosis the following must be considered: pathological fracture, congenital defects, general systemic disease, metastasis, primary bone tumors, Paget's disease, osteomalacia, rickets, tuberculosis, syphilis, osteomyelitis, and simple fracture due to violence. SYDNEY J. HAWLEY, M.D.

Pathology, Clinical Manifestations, and Treatment of Lesions of the Intervertebral Disks. Albert Oppenheimer. New England J. Med. **230:** 95–105, Jan. 27, 1944.

This is an extensive article discussing the development, cause, and pathology of changes in the intervertebral disks and their sequelae.

As the result of repeated traumata to the spine, the intervertebral disk seems to receive a greater amount of injury than the bone structure. The cartilage undergoes degeneration, with increased fibrosis, loss of turgor and volume. This results in flattening of the disk, narrowing of the intervertebral space, displacement of the articular processes, and narrowing of the neural foramen. Arthritic changes may appear at the zygapophyseal joints.

The clinical evidence depends upon the secondary changes rather than the primary injury and alteration in the intervertebral disk. The symptoms arise from the arthritic change and the compression of the nerve as it passes through the neural foramen. The signs and symptoms of this radicular neuralgia and neuritis are often indistinguishable from those of myalgia, peripheral arthritis, bursitis, and pain referred from diseased viscera.

The treatment is surgical or conservative. Conservative therapy consists chiefly in irradiation of the spine. JOHN B. MCANENY, M.D.

Fresh Fractures of the Carpal Scaphoid. Benjamin E. Obletz. Surg., Gynec. & Obst. **78:** 83–90, January 1944.

Fractures of the carpal scaphoid occur almost exclusively in vigorous young men and are therefore frequently found in army training camps. The author bases his study on 45 consecutive cases seen during an eighteen-month period.

The carpal scaphoid has a constricted "waist," where most of the fractures occur. The majority of these bones have an adequate blood supply to both proximal and distal portions as demonstrated by arterial foramina along the entire length of the bone. Sometimes, however, there are no arterial foramina proximal to the waist, and in these instances a fracture through the waist could interrupt the blood supply to the proximal fragment.

In most cases the fractures are caused by a fall on the outstretched hands. The chief complaint is of a painful wrist, and this pain also limits movement. There is usually local tenderness but no swelling.

Roentgenograms of the injured wrist are made in four positions, all on a single 10 × 12-in. film, the usual anteroposterior and lateral views being supplemented by an anteroposterior view in ulnar deviation and a postero-anterior at 45 degrees oblique. With these additional views it is much easier to recognize the often almost invisible line of fracture at the time of injury. Once the diagnosis is made, subsequent serial roentgenograms are taken in the single ulnar deviation position. The author suggests that overexposure is a pardonable sin in these cases.

The fluids at the fracture site become acid from the 4th to the 7th day and cause absorption of the adjacent bone, the fracture line becoming wider and more apparent. There is also a reactionary hyperemia of the bones of the injured wrist during the first few weeks following fracture, which results in decalcification and osteoporosis of the wrist bones. The decalcification is usually mild, but may be severe, and because of the tendency to atrophy due to lack of use, recalcification may be delayed long after the usual two weeks of hyperemia is past, until healing permits renewed use of the wrist. Should the wrist be incompletely mobilized, the resulting irritation and trauma at the fracture site will greatly prolong the stage of hyperemia, and the decalcification will be more pronounced and of longer duration. Since decalcification is dependent on a state of hyperemia in the bone, interference with the arterial blood supply prevents loss of calcium in the affected area. Retention of normal calcium density, therefore, in a fractured bone is proof of its avascularity.

Since the carpal scaphoid is a cancellous bone, no subperiosteal callus is formed, and disappearance of the fracture line must be relied on to indicate healing. Persistence of the line beyond twelve weeks indicates delayed union.

If movement between the fractured surfaces is permitted by inadequate immobilization of the wrist, fibrous and fibrocartilaginous tissue will form at the fracture site while adjacent tissue becomes sclerotic and eburnated. This condition of non-union is indicated on the roentgenogram by a widened, translucent fracture line bounded on either side by a dense white margin.

The fractures studied by the author are divided into two groups, those with and those without interruption of the blood supply to the proximal fragment. Eight cases composed the former group.

Roentgenograms made at the time of injury show either an easily recognized fracture or a hair-line fissure which is barely visible. There is usually no displacement of the fragments. The scaphoid and the adjacent bones show a uniform and normal density. Three or four weeks after injury the fracture line is more distinct and there is a diffuse homogeneous decalcification of all the carpal bones, including both fragments of the damaged scaphoid if the blood supply has not been cut off. In those instances where the blood supply to the proximal fragment has been interrupted, there is no decalcification of that portion, and its original density remains unchanged; hyperemia is absent, and the absorption of calcium prevented.

Six to eight weeks after injury the general osteoporosis of the carpals is usually more pronounced in those cases with an interrupted blood supply, and as a result the dense proximal fragment is more noticeable. In these cases, too, the fracture line is still visible, while in many with normal circulation has disappeared.

At twelve weeks there is still a noticeable difference in density of the proximal fragment, but the fracture line now shows signs of healing in spite of the damage sustained by the blood supply.

At sixteen to twenty weeks, the relative density of the fragments is much less marked, and the fracture line has been obliterated by the healing process.

Removal of the cast will insure a return of normal calcium density to the carpal area within a few weeks, and subsequent roentgen examinations will disclose no degenerative processes in the scaphoid. It is evident that the dense white shadow of the proximal fragment is evidence of avascularity, not of aseptic necrosis. Bone cells die slowly when deprived of their blood supply and, since the avascularity of the fragment is temporary and soon relieved by vascular granulations bridging the fracture line, necrosis is entirely prevented. If the wrist is not properly immobilized, vascular bridging of the fracture line may be prevented, and necrosis of the fragment may result. The importance of proper immobilization is obvious. If it is complete, continuous, and maintained until healing has occurred, surgery will be unnecessary.

The author's method of treatment consists of a plaster-of-Paris gauntlet extending from the distal palmar crease to the elbow, including the proximal phalanx of the thumb. The wrist is fixed in a few degrees of dorsiflexion, the thumb in a relaxed position. The patient is urged to use his fingers freely, and his activity is not restricted. The cast is replaced if it breaks or softens and at the time of the serial x-ray examinations. In all the cases results were favorable as far as they could be ascertained. The average time of healing in cases without damage to the circulation was 8.3 weeks; with interruption of circulation in the proximal fragment 19 weeks were required on an average for complete disappearance of the fracture line.

D. W. TOWNSEND, M.D.

Subscapular Ossified Hematoma. Case Report. J. William White and Sydney Hunter. Am. J. Surg. **63:** 124–130, January 1944.

The authors define a hematoma as a confined hemorrhage, in which clotting may or may not have taken place, which would include the hemorrhagic accumulations in serous cavities usually designated as hematoceles, hematocysts, blood cysts, or more specifically as hemothorax, hemarthrosis, etc. Trauma is a common etiologic factor.

Small, uncomplicated hematomas are accompanied by few, if any, symptoms and tend to resolve quickly. Hematomas of larger proportions are symptomatic, although they may be concealed by more obvious and serious lesions. Collections of blood which are not successfully evacuated pass through phases similar in some respects to the process of tissue repair, *i.e.*, resolution, fibrosis, suppuration, or, in rare instances, ossification.

Ossification occurs with greatest frequency in hematomas about the elbow joint and in the thigh. Often manifested as a later transition product, calcium deposits have been demonstrated roentgenographically early in the third week following injury. Serial x-ray films of ossifying hematomas show a progression from flocculated calcium islets to complete replacement by lamellations of compact and cancellous bone. Eventually, the inflammatory barrier found at the periphery of a hematoma is converted into a neomembrane,

grossly resembling periosteum and serving as a capsule at the circumferential limits of ossification.

The case recorded here occurred in a soldier, who complained of a "lump in the right shoulder, with numbness and tingling of the right hand." Twenty-two years previously he had sustained a severe crushing injury of the right shoulder. Treatment was promptly instituted; a plaster jacket was worn for three months, followed by physiotherapy in an effort to relieve persistent numbness in the hand. A cock-up splint was applied to the forearm and hand and this was maintained for a year and a half. A sensory disturbance persisted, but a swelling above the clavicle and in the axilla was not discovered until several years after the injury. This tumefaction was not believed to have increased in size over a period of fourteen years.

The patient continually supported his right hand in the opposite palm and maintained the arm at a 20-degree angle of abduction. The vertebral border of the corresponding scapula was rotated posterolaterally. Pain, which radiated along the ulnar surface of the arm and forearm, was induced by elevating the arm above the shoulder level and by elevating the chin forcibly while the head was rotated toward the side of the lesion. An obliquely directed ovoid, non-tender, solid, regularly surfaced tumor, movable vertically, medially, and laterally within narrow limits, occupied the right subscapular, axillary, and supraclavicular fossae.

Stereoscopic x-ray films showed a large irregular calcified mass measuring 14 × 6 cm. between the scapula and thoracic wall. This mass was sharply demarcated from the surrounding soft tissues and was not attached to any bony structure, although the upper four ribs were flattened against the lateral lung surface, thus narrowing the costal cage, and the scapula was moderately displaced backward. A tangential view after the injection of 30 c.c. of diodrast into the median basilic vein showed satisfactorily the basilic and axillary veins. The axillary vein was displaced anteriorly and 1.5 cm. above the calcified mass.

On removal the tumor proved to be an ossified hematoma, measuring 13 × 11.5 × 5.5 cm. and weighing 390 gm. The function of the arm was completely restored, although there was a tendency to hold the distal phalanges of all digits in partial flexion; the numbness and tingling were relieved.

The deformity of the ribs and displacement of the scapula in this case suggest a peripheral deposition of calcium which, as the mass increased in volume, compressed the relatively less fixed adjacent structures. Early involvement of the medial cord of the brachial plexus was assumed from the history of numbness, which persisted from the time of injury. Pain and tingling were of more recent origin and were probably due to a slowly progressive peripheral extension, involving the nerve trunk and producing mild, but increasing, vascular symptoms.

The primary objective in the treatment of ossified hematoma should be prevention. Rest, passive motion, heat, diathermy, and massage are of benefit in some cases. The optimum time for surgical intervention has not been clearly defined. Too early removal may result in recurrence or extension of calcification; too late, in permanent pressure damage to adjacent vessels and nerves. The authors recommend waiting a year before making an attempt to excise an ossified hematoma, provided relief from neurovascular symptoms is not more urgent.

Two Congenital Deformities of the Tibia: Congenital Angulation and Congenital Pseudarthrosis. E. Rohan Williams. Brit. J. Radiol. **16:** 371–376, December 1943.

Congenital angulation (kyphosis) of the tibia is obvious at birth. It is probably caused by deficient growth of the muscles. It is frequently associated with absence of the fibula and sometimes with other skeletal anomalies. The angulation occurs at the junction of the middle and lower thirds. There is a marked talipes equinus, and the whole limb is short and thin. The skin is puckered at the site of the angulation. The condition may be bilateral. Two cases are presented.

Congenital pseudarthrosis is of unknown cause. It is a purely local condition, apparently due to a deficiency of bone formation. It may be related to, or a form of, osteitis fibrosa cystica. Cases seen before fracture occurs show an anterior bowing of the lower half of the tibia. X-ray examination reveals a zone of osteoporosis or a multilocular cystic area with moderate cortical expansion. After fracture, which is of common occurrence, frank pseudarthrosis may be present or there may be partial attempts at healing. The angulation becomes progressively worse. There is no talipes equinus or dimpling of the skin with congenital pseudarthrosis. The treatment should be non-operative until the age of about seven years. Two cases are presented.

SYDNEY J. HAWLEY, M.D.

Internal Derangements of the Knee Joint in the Canadian Army (Overseas). D. W. MacKenzie and J. A. MacFarlane. Canad. M. A. J. **49:** 472–478, December 1943.

This is a review of 303 cases of internal derangement of the knee joint necessitating arthrotomy, followed postoperatively for three to thirty months. The average age was 28 years and the average duration of disability two years. In 90 per cent of the cases there was a history of injury.

Preoperative radiological examination proved to be of importance, since of those patients for whom radiological records were available (82 per cent of the series), 27 per cent revealed some abnormality of the knee joint and the number of patients postoperatively unfit for service in this group was almost five times greater than among those with negative radiographic findings.

The importance of care in diagnosis and surgical conservatism is emphasized. Findings show that small incisions and subtotal meniscectomy usually suffice; operation following first injury is not advised except in cases where a locked knee resists reduction under anesthesia. Important factors in determining the necessity for surgery are age, mechanism of injury, and character and duration of disability. The importance of preoperative instruction in quadriceps exercises is stressed.

MARIE L. CONNELLY, M.D.

Use of Special Views in Roentgenography of the Knee Joint. John D. Camp and Mark B. Coventry. U. S. Nav. M. Bull. **42:** 56–58, January 1944.

The authors believe that a complete radiographic examination of the knee joint should include a film of the intercondylar notch. For this view, the patient is placed in the prone position, with the affected knee flexed to an angle of 40° and supported by sandbags. The film is centered 2 1/2 inches below the center of the joint and the tube angled 40°, centering to the film.

In this position the intercondylar notch is projected clear of the patella and tibia.

Moreover, when any disturbance of the patella is suspected, special views of this structure in the vertical and transverse planes should be included. With these additional exposures information not readily apparent on the conventional examination may be obtained.

ELLWOOD W. GODFREY, M.D.

Complete Roentgen and Ophthalmologic Examination for Ochronosis in Two Alcaptonuric Children. Lynn D. Abbott, Jr., Frederick B. Mandeville, and Walter J. Rein. Virginia M. Monthly **70:** 615–617, December 1943.

The author made complete roentgen examinations and ophthalmologic studies on two colored children aged ten and fifteen years, proved to have alkaptonuria, to determine whether any evidence of ochronosis was present. While the latter condition is usually believed to be due to an accumulation of pigment over a period of years and is generally held to develop in the presence of alkaptonuria only in middle age or later, evidence of the disease has been reported in the eyes as early as the third decade.

According to Pomeranz, Friedman, and Tunick (Radiology **37:** 295, 1941), the roentgen findings in adults with alkaptonuric ochronosis include changes in the large joints, especially in the dorsal and lumbar articulations, resembling those often found in severe and extensive osteoarthritis of the Marie-Strümpell-Bechterew type, with calcification of the intervertebral disks and cartilages, bridging, and eburnation at weight-bearing surfaces.

The findings in the authors' patients were entirely negative for ochronosis. Epiphyseal development was normal, with normal bone age. The skull vault and sella turcica were normal. Special films of the cartilages of the ears after the technic of Fuchs showed no abnormal areas of cartilage or calcific deposits. Fluoroscopy and films of the chests showed the lungs to be perfectly clear.

Ophthalmologically the eyes showed some alterations due to melanosis but changes attributable to alkaptonuria could not be ascertained. The younger of the two patients, a girl, who excreted the larger amount of homogentisic acid, showed a greater degree of scleral pigmentation than the older, a boy, with a lesser degree of alkaptonuria. J. E. WHITELEATHER, M.D.

OBSTETRICS AND GYNECOLOGY

A Practical Technique for Roentgen Pelvimetry with a New Positioning. A. E. Colcher and Walter Sussman. Am. J. Roentgenol. **51:** 207–213, February 1944.

A simplified technic for roentgen pelvimetry is described utilizing a new position for an anteroposterior view. The method employs a rotating metal rule marked off in centimeters and held parallel to the table-top by means of an upright standard. For the lateral view the patient is positioned in the usual fashion with the tube centered over the greater trochanter. The ruler is placed at the mid-sacral spine, parallel with the spine and film. For the anteroposterior view the patient is placed flat on the back with the knees semiflexed and separated. This elevates the forepelvis and brings the bituberal, bi-ischial and transverse diameters of the inlet practically on the same level and in the same plane as the table and the film. The ruler is placed at the level of the tuberosities of the ischium by direct manual palpation or by lowering the ruler 10 cm. below the superior border of the symphysis pubis. This latter measurement was determined by a study of dried pelves and clinic subjects and was found to be satisfactorily accurate.

It is pointed out that the actual inlet starts from the inner upper margin of the symphysis and extends along the iliopectineal line through the level of the transverse diameter of the inlet and is projected to the sacrum. The anteroposterior diameter of this strait extends from the upper inner margin of the symphysis to a point on the sacrum midway between the brim of the pelvis above and the sciatic notches below. The sum of this diameter and the transverse diameter as measured in the anteroposterior view varies from 22 to 24 cm. in the normal. In a similar manner the anteroposterior and transverse diameters of the mid-pelvis and of the outlet can be measured and added. Those of the mid-pelvis should average between 20 and 22 cm. and those of the outlet between 16 and 18.5 cm. The fetal head when presenting in the mid-line can be measured in both the lateral and anteroposterior views. The method requires only two exposures and the ruler gives direct centimeter measurement on each film without need of correction tables. L. W. PAUL, M.D.

The Subpubic Angle: Radiological Aspects. E. Peter Allen. Brit. J. Radiol. **16:** 279–282, September 1943.

The importance of a narrow subpubic angle in producing delay in the last stage of labor is well understood, yet its radiological measurement is as yet unsatisfactory. The method of Chassard and Lapiné, in which a special film is made with the patient astride the cassette, stooping forward until the plane through the symphysis pubis and ischial tuberosities is parallel to the film, is subject to one serious error: there is no accurate way to check the position accurately. The method of Caldwell and Moloy, with the patient supine and the beam directed at an angle of 45 degrees toward the symphysis and approximately perpendicular to the descending rami of the pubis, is even less satisfactory, for it is subject to two errors: variations in the angle of the pelvis and inaccurate setting of the central beam. The method of Ince and Young, in which the angle is calculated from anteroposterior and lateral films, does not take into consideration the shape of the subpubic area.

The author advocates using a film made by the Chassard and Lapiné method plus an overlay transparency with a base line 10 cm. long, at the center point of which is erected a measured perpendicular. The base line is placed parallel to the line joining the ischial tuberosities and so that the ends touch the sides of the subpubic arch. The height of the lower edge of the symphysis is read on the perpendicular and is an index of the shape and width of the angle.

SYDNEY J. HAWLEY, M.D.

THE GENITO-URINARY TRACT

Osteo-Nephropathy: A Clinical Consideration of "Renal Rickets." Colter Rule and Arthur Grollman. Ann. Int. Med. **20:** 63–74, January 1944.

The association of bone changes and renal disease has for some time been designated as "renal rickets."

In view of the pleurality of underlying disorders responsible for the clinical syndrome, the authors suggest that the term "osteo-nephropathy" be substituted, since it indicates the nature of the presenting symptoms without implications as to the pathogenesis. They present the following etiologic classification:

A. Due to primary urinary tract disturbances
   1. Chronic glomerulonephritis, pyelonephritis, nephrosis
   2. Congenital malformations: Polycystic kidneys, renal hypogenesis
   3. Urinary tract obstruction with secondary renal lesions: Urethral valves; prostatic enlargement; calculi; strictures of urethra, bladder neck or ureter; hydroureter
   4. Primary tubular functional changes which may or may not show anatomical changes.
      (*a*) Hypochloremic-glycosuric type (deToni-Fanconi syndrome)
      (*b*) Hyperchloremic type without glycosuria

B. Due to primary extra-renal disturbances
   1. Endocrine disease
      Hyperparathyroidism (osteitis fibrosa cystica)
   2. Metabolic disturbance
      Cystine storage disease.

The symptoms depend on the fundamental nature of the disorder and on the extent and duration of the renal damage. In most instances, the bones show generalized osteoporosis, deformities (genu valgum or varum, Harrison's groove, rachitic rosary, pigeon breast), and dwarfism. Renal disturbances account for the commonly observed symptoms of nocturia, polyuria and polydipsia, signs of acidosis, and the terminal picture of uremia.

The x-ray film, in some cases, may indicate the fundamental disorder by showing bone cysts, characteristic of primary hyperparathyroidism, calcification in the kidney, or other changes in the genito-urinary tract. In advanced stages there is a greater translucency of the shafts of the long and flat bones and a more porous appearance than in true rickets. Multiple healed fractures may be present.

The blood chemistry and urinary findings are important for the determination of the actual nature of the disease, and these the authors tabulate for the various types.

The great majority of cases of osteo-nephropathy are due to primary renal disease with well recognized anatomical changes, *i.e.*, groups 1, 2, and 3 under A in the authors' classification. In these cases treatment is directed essentially to the underlying renal disease. Some success is reported with alkali therapy. Vitamin D in daily doses of 20,000 or 30,000 units may result in some healing. Calcium may be given to counteract the tendency of alkali to precipitate tetany. Treatment of the hypochloremic-glycosuric type has been disappointing. In the hyperchloremic type good results were obtained by the authors (in a single case) and by Albright *et al.* (Bull. Johns Hopkins Hosp. **66:** 7, 1940) with a low-salt diet, dibasic calcium phosphate daily (6 gm. in divided doses in milk), vitamin D (20,000 units daily), and 30 c.c. of a sodium citrate and citric acid buffer mixture three times a day, half an hour before meals.

Hyperparathyroidism in children is encountered rarely, and the differentiation of osteo-nephropathy due to this cause will seldom present difficulty. Parathyroidectomy is followed by good results in cases which are not too far advanced.

Two cases are reported. In the first, secondary to renal tubular dysfunction, the roentgenographic examination of the long bones revealed extensive changes at the proximal and distal ends characteristic of rickets. The diaphyses and metaphyses showed extensive osteoporosis, with marked underdevelopment of all the epiphyseal centers. A flat plate of the abdomen showed shadows of calcareous density arranged in clusters around the kidney pelves and minor calices. Four months later, subsequent to the dietary régime mentioned above, the roentgen examination of the wrists and ankle joints showed marked changes in the appearance of the epiphyses, with considerable calcification and definite evidence of healing of previous rachitic changes. No reduction of renal calcification was evident. Photographs of this patient and roentgenograms showing the bone changes are reproduced.

In the second case, in a 16-month-old girl, roentgen examination of the long bones revealed indistinct outlines of the epiphyses, which were undeveloped and decalcified, with widening of the epiphyseal line, characteristic of active rickets. A flat plate of the abdomen revealed moderate enlargement of the hepatic and splenic shadows. Intravenous and retrograde urography showed bilateral rotation and hydronephrosis, the dilatation being most marked on the right side. The left ureter was dilated and tortuous. The bladder was small and showed a persistent inverted funnel-shaped deformity. The patient was placed on a high potassium diet with added dicalcium phosphate and vitamin D and potassium citrate buffer solution, but the results are not mentioned.

STEPHEN N. TAGER, M.D.

THE VASCULAR SYSTEM

Localized Arterial Thrombosis of Indeterminate Origin. J. R. Learmonth, W. Blackwood, and R. L. Richards. Edinburgh M. J. **51:** 1–20, January 1944.

Reports of 4 cases of localized arterial thrombosis of undetermined origin in young adults are presented. Vasomotor reactions were studied in all and in 2 a detailed histologic examination of the affected artery was made. The arteriographic findings in 3 of the cases are illustrated. These show a filling defect in the main artery, beginning and ending "squarely." Occasionally active collateral vessels may be seen arising from the thrombosed segment. In general, collaterals are, as is to be expected, dilated and tortuous, especially after sympathectomy.

Arteriography is of particular aid as a guide to treatment. When the length of the blocked segment is extensive, and the thrombus appears to be approaching the mouths of vessels of known anatomical collateral importance, arteriectomy may be undertaken. In such circumstances, all branches arising from the thrombosed segment must be tied close to the parent trunk, in order to preserve the reversal of circulation which occurs at the bifurcation of such branches. On the other hand, inspection of the arteriogram may show that arteriectomy would be difficult if not impossible with preservation of a branch which is contributing substantially to the collateral circulation.

FOREIGN BODIES

A Practical Method for Localization and Removal of Foreign Bodies. W. S. Hotchkiss. Virginia M. Monthly **71:** 37–38, January 1944.

In the method described in this paper, the foreign body is visualized on the fluoroscopic screen. The skin area over the site is prepared and a 10-c.c. syringe of 1 per cent novocain with two small caliber needles of adequate length is obtained. Under fluoroscopic visualization one needle is introduced into the skin at a slight angle. Infiltrating novocain ahead, the needle is brought into contact with the foreign body. This can be felt by both the operator and the patient as well as seen on the screen. The syringe is then removed and the needle left in place. The second needle is applied to the syringe and the same procedure repeated from a different point. Thus, the points of the two needles meet at the actual site of, and in contact with, the foreign body. The patient is then removed to the operating room, and under local anesthesia it is the simplest of tasks to cut down to the juncture point of the needles and remove the foreign body.

This procedure has the advantage of not immobilizing both x-ray equipment and trained personnel for any considerable period of time. Also, it is possible to maintain perfect asepsis. The method requires no special instrument, is simple and accurate, and no extra expenditure of x-ray plates is necessary.

J. E. WHITELEATHER, M.D.

RADIOTHERAPY

NEOPLASMS

Adenolymphoma of the Parotid Salivary Gland. M. Lederman. Brit. J. Radiol. **16:** 383–385, December 1943.

Adenolymphoma of the parotid gland is a slow growing tumor, for the most part benign, usually found in males over 40. Only rarely is it bilateral. It seldom produces symptoms, and the diagnosis is based on microscopic examination. The treatment is usually surgical, but the tumor will respond to irradiation in high doses.

Four cases are reported, of which one was malignant. This latter case (Case I) was treated by excision of the tumor, dissection of involved lymph nodes, and teleradium. In spite of the histologic resemblance of the tumor to squamous carcinoma and the presence of ineradicable metastases in the cervical lymph nodes, the patient survived ten years from the institution of treatment.

Teleradium therapy was also used in the three benign cases. As to the results, the author says: "That resolution of benign adenolymphomata can be effected by radiotherapy alone is shown by Cases II and IV. In Case II excision of the tumour on the right side was incomplete, and post-operative implantation of radium was obviously effective in eradicating the tumour residue since there was no recurrence up to the time of death six years later. Similarly, there was no recurrence within three years after teleradium treatment to the tumour on the left side. In Case IV, complete disappearance of a recurrent adenolymphoma followed teleradium treatment with no recurrence to date (15 months). In Case III, a fixed, non-encapsulated recurrence was excised and followed by post-operative teleradium, and there was no recurrence for a period of four years. In this instance, however, it is impossible to be certain that any tumour tissue remained after excision, although the clinical and macroscopic features of the recurrent tumour did not suggest that it was of a very localised nature.

"The doses employed in the treatment of the benign tumours are of interest. In Case II, the right tumour received a tumour dose of 4750 r in 91 hours by implantation and the left 5000 r (approximately) in 21 days by teleradium. In Case III, the dose given to the scar area was 4500 r in 12 days. In Case IV, the tumour dose was 5000 r in 29 days. It would seem, therefore, that benign adenolymphoma can be expected to respond satisfactorily to doses of the order of 5000 r, using either post-operative implantation over a period of 7 days or less, or external radiation over a period of 3–4 weeks." SYDNEY J. HAWLEY, M.D.

Carcinoma of the Parathyroid Gland. Karl A. Meyer and Alex B. Ragins. Surgery **14**: 282–295, August 1943.

A case of carcinoma of the parathyroid gland with diffuse fibrocystic disease of the bone is presented, with a detailed postmortem report.

The patient experienced a temporary improvement in the objective and subjective symptoms following extirpation of the tumor twenty-six months before death. After approximately eight months, however, the subjective symptoms reappeared and a year later the fibrocystic skeletal changes became progressively worse despite x-ray irradiation to tumor and bone. There followed a number of pathological fractures with a definite rise in serum phosphorus indicating renal decompensation.

It is of interest that numerous areas of calcification were demonstrated in the soft tissues, particularly the pyramids of the kidney. Calcification was also observed in metastatic lesions of the lymph nodes, in the thyroid, the urinary bladder, and the blood vessels of the heart. There was almost complete destruction of the cortex of the bone. The predominating cell resembled the chief cell, although transitional cells and water-clear cells were occasionally seen.

The effect of radiation in primary hyperplasia of the parathyroid is still a moot question. This patient failed to improve under rather extensive x-ray treatment.

The essential postmortem findings were as follows: recurrent carcinoma of the parathyroid gland with metastases in the peritracheal, subclavicular, and perijugular lymph nodes, the lungs, and the right kidney; generalized osteitis fibrosis cystica; bilateral nephrolithiasis, bilateral chronic ascending pyelonephritis, left pyonephrosis with atrophy of the renal cortex and nephrocalcinosis. J. E. WHITELEATHER, M.D.

Classification of Laryngeal Cancer from a Radiotherapeutic Viewpoint. M. Lederman. Brit. J. Radiol. **16:** 298–300, October 1943.

A more informative classification than the usual "intrinsic" and "extrinsic" type of cancer of the larynx is suggested, as follows:

A. Endolaryngeal
   1. True vocal cord
   2. Ventricle, false cord and infrahyoid epiglottis
   3. Subglottic space
   4. Commissure
      (*a*) Anterior
      (*b*) Posterior

B. Laryngopharyngeal
   1. Epilaryngeal
      (*a*) Suprahyoid epiglottis
      (*b*) Aryepiglottic folds
      (*c*) Arytenoids
   2. Walls of the laryngopharynx
      (*a*) Postcricoid
      (*b*) Pyriform fossae
      (*c*) Lateral and posterior walls

This classification fits better the problems presented by the choice of treatment and the prognosis.

SYDNEY J. HAWLEY, M.D.

Cancer of the Larynx: A Radiotherapeutic Test as an Aid in Choosing Between Operation and Irradiation. Max Cutler. Arch. Otolaryng. **39:** 53–58, January 1944.

In 1941 Cutler described his "concentration technic" of radiotherapy for carcinoma of the mouth, pharynx, and larynx (J. A. M. A. **117:** 1607, 1941. Abst. in Radiology **38:** 635, 1942). At that time he found that interrupted treatment—*i.e.*, two cycles with an interval of eleven to fifteen days—was equally as effective as continuous treatment. He now advocates the application of the interrupted technic as a radiotherapeutic test in cancers of the larynx which are too far advanced for laryngofissure but are suitable for either laryngectomy or radiotherapy and in those in which general conditions seem to favor radiotherapy in preference to surgery. Fifteen days after completion of the first roentgen cycle it is possible to judge the response and estimate the relative radiosensitivity of the lesion with reasonable accuracy. If there has been little or no response, the second cycle is omitted, and laryngectomy is performed in four to six weeks. If the response has been favorable, the second cycle of radiotherapy is administered.

This method has been employed in 25 cases of cancer of the larynx and a typical case is reported. A total dose of 3,600 r (measured on the skin) was given in the first cycle. This produced a considerable regression of the tumor and increased mobility of the hemilarynx. Thirty-eight days after the completion of the second cycle, in which 4,000 r were given, there remained only a small, irregular, non-ulcerated nodule about 6 mm. in diameter on the posterior extremity of the right true cord. A third course of roentgen therapy, 2,000 r, was therefore administered, bringing the total dosage for the three cycles to 9,600 r. At the time of this report, approximately fourteen months after the initial roentgen treatment, the patient had gained weight, his voice was normal, and the hemilarynx was normal in appearance and mobility.

The therapeutic test enables one to choose the best treatment for the particular laryngeal cancer under consideration. Laryngectomy should not be withheld if it offers a greater chance of cure; on the other hand, the patient should be given the advantage of cure by roentgen therapy without laryngectomy if the circumstances warrant.

Technique of Radium Treatment of Intrinsic Cancer of the Larynx. M. Lederman and W. V. Mayneord. Brit. J. Radiol. **16:** 301–307, October 1943.

Individualization of treatment is nowhere more important than in intrinsic cancer of the larynx. Good results cannot be expected from standardized methods.

Teleradium methods can be successfully individualized. These are particularly suitable for laryngeal cancer, as homogeneity of distribution is not as important here as high localization. The absence of a high depth dose as in x-ray therapy is also an advantage.

Six specimen technics are worked out in detail for different intralaryngeal situations. Of 15 patients treated five years ago by these methods, 9 are free from disease.

SYDNEY J. HAWLEY, M.D.

X-Ray Treatment of Carcinoma of the Œsophagus. D. Waldron Smithers. Brit. J. Radiol. **16:** 317–322, October 1943.

This paper describes the application of Mayneord's method of three-dimensional depth dose calculation in esophageal carcinoma. The patients were accurately placed and every effort was used to prevent damage to normal structures. Six fields were treated daily. A tumor dose of 6,000 to 7,000 r was given in five to six weeks.

Forty-four patients were treated, 32 completing the series, and of these 3 are alive and well, one six years and four months, one five years and one month, one four years and nine months after treatment. Symptomatic relief was obtained in 30 patients; 11 became entirely symptom-free for varying periods of time. Fourteen lived for one year or more and 5 for two years or more. Three were found at necropsy to have no sign of residual ulcer or cancer.

SYDNEY J. HAWLEY, M.D.

Carcinoma of the Uterine Cervix: Treatment and Prognosis. Daniel G. Morton. West. J. Surg. **52:** 1–10, January 1944.

The five-year survival rate of carcinoma of the cervix in patients treated with radium in the University of California Medical School from 1928 to 1931 was 15.2 per cent. This was increased to 35.2 per cent in patients treated from 1931 to 1938 by the additional use of high-voltage roentgen therapy with radical panhysterectomy in selected cases.

Large everting growths are first treated by external irradiation (200 kv. or 1,000 kv.), as much as 4,000 r being delivered to each of four pelvic ports. This is followed in three or more weeks by radium application, the basic dose being 4,500 mg. hr.: 3,000 mg. hr. distributed in the cervico-uterine canal, usually by a tandem of three capsules, and 1,500 mg. hr. in the form of a plaque against the cervix. The total dose is given in three weekly treatments. Roentgen treatment is not without danger and in patients of advanced age or markedly debilitated the dosage is reduced.

Complications of pelvic irradiation include bowel obstruction, visceral bleeding and pain, ureteral stric-

ture, and fracture of the femoral neck. In 18 of 374 patients death was believed to have been precipitated by roentgen therapy. The chief complication of radium treatment is the spread of infection. The use of x-rays first, however, helps to prevent this danger. Fistulas are occurring less frequently and when present are usually due to progression of the growth.

Wertheim panhysterectomy was performed in 100 selected cases of Stage I and II carcinoma (Schmitz) and the author compares the results with those of irradiation in these stages. For 76 cases treated with radiation alone the five-year survival rate was 48.6 per cent; in 56 operated cases 64.2 per cent. The ten-year survival rate was 34.0 per cent of 47 cases treated by irradiation and 58.3 per cent of 48 cases operated upon. Operation should be done only where clinically the new growth is confined to the cervix. The patient should not be older than 55 years and should be in good general condition to survive the shock of surgery; she must not be obese and should have good arm or ankle veins for infusions and transfusions if needed. Although x-ray and radium treatment may make the operation more difficult because of possible fibrosis in the pelvis, this is considered more than offset by the reduction of infection and a lowered incidence of peritonitis. There has been a mortality rate of 2.7 per cent in 78 patients operated upon in the past twenty years.

Urinary fistulas occurred as an operative complication in 13 cases, most of which were either repaired successfully or healed spontaneously. When the parasympathetic fibers to the bladder were partially or completely sectioned, there was loss of sensation of bladder fullness and the patients were unable to control the sudden emptying. Adequate bladder control, however, was re-learned in a few weeks or months at the most.

In prognosis the clinical classification is the most useful factor. The following chances of cure are predicted: Operable Stage I, in young women in good general health suitable for operation: 9 out of 10; Inoperable Stage I, in older women, obese patients, and others in whom operation is unwise: 3 out of 4; Stage II: 1 out of 2; Stage III: 1 out of 4 or 5; Stage IV: 2 or 3 out of 100. LESTER M. J. FREEDMAN, M.D.

Physical Aspects of Intracavitary Radium Treatment of Carcinoma of the Cervix Uteri. Part I. G. J. Neary. Brit. J. Radiol. **16:** 225–233, August 1943.

The objective in the treatment of cervical carcinoma should be to deliver a dose spatially so distributed that all the malignant cells will be destroyed without producing a dangerous over-reaction in the normal or malignant tissues. Whether or not this can be done depends upon the distribution of the malignant cells.

The present discussion is based upon the following conclusions: (1) The disease is in a large proportion of cases confined to the pelvis. (2) The general trend of spread is laterally. (3) Intracavitary radium plays a fundamental part in the treatment of the disease; the improvement of results by adding supplementary x-ray is disappointingly small.

Anatomical data regarding the lymphatic spread is conflicting. It is apparent, however, that the attention should be directed primarily to the middle node of the medial chain of the external iliac group, 5 to 6 cm. on either side of the cervix.

The objective should be to deliver a certain dose to a point (A) in the parametrium adjacent to the cervix, to give as great a dose as possible to the principal lymph node (B), and to give a safe dose to the rectovaginal septum opposite the cervix (S).

The uterine applicator alone gives B only about 22.5 per cent of dose at A. The radium near and at the internal os has the greatest effect at A. If it were desirable to improve the ratio between B and A, the radium would have to be removed from the internal os. The ratio of the doses at A and B from vaginal radium depends on the distance. Improvement in the ratio results by increasing the anteroposterior diameter of the vagina at the expense of the lateral, rather than pushing the radium laterally as far as possible.

Combining the two effects, it is found that with fixed and comparable quantities of radium in uterus and vagina, a lateral separation of the vaginal radium sources hardly affects the total dose rates at A and B, while a displacement toward the posterior wall reduces both dose rates almost to the same proportion, so that the combined depth dose ratio of B to A is very little affected by the position of the radium in the vagina, whether it is pushed into the fornices or anywhere else. The specific ratio for the vaginal applicator is usually at least twice that for the uterine applicator, and it is of no value to improve this ratio further while the poor ratio of the uterine applicator has a preponderating effect on the combined ratio of B to A. Thus, apart from altering the distribution of radium in the uterus, the only thing to do is to increase the relative amount of radium in the vagina.

The rectal dose is derived almost entirely from the vaginal radium. If the usual two radium sources in the vagina are combined into one in the mid-line, it will be found that there is little effect on the ratio of the doses at A and B and the dose at S will be reduced, as this permits expanding the anteroposterior diameter at the expense of the lateral.

It is seen, then, that according to the author's formal scheme a single midline source gives a better distribution of radiation.

By calculation of the ratio of radium in the uterus and in the vagina under these circumstances, it is found that when the rectal dose is not markedly less than the dose at A, and when the specific ratio of the uterine applicator is about 0.22, the best dose distribution is obtained when the uterine applicator is left out entirely.

These observations have two clinical applications of significance: (*a*) the use of a heavy absorber, as gold or platinum, instead of gauze between the vaginal radium and the rectovaginal septum; (*b*) a drastic modification of the uterine applicator.

A rectal screen of platinum of 1 cm. thickness would suffice to cut the rectal dose to about 30 per cent of its original level so that it would be possible to bring the radium source in the vagina closer to the rectum, and so increase the depth dose ratio of B to A. Or the lateral diameter of the vagina could be increased again and the dose on all the mucosa of the vagina reduced considerably. In fact, the use of an absorbing screen over the rectum should give extraordinary advantages.

Alteration of the uterine applicator so that the radium is concentrated at about 3 cm. above the internal os will give a better ratio of doses at A and B and will permit smaller doses from the vaginal applicator.

These changes require the use of larger amounts of radium than have heretofore been advocated. The use of a platinum absorber will offset the danger to the

rectum. Even with the larger quantities of radium, the total dose is less than with combined radium and x-ray, and a better spatial distribution is obtained.

SYDNEY J. HAWLEY, M.D.

Physical Aspects of Intracavitary Radium Treatment of Carcinoma of the Cervix Uteri. Part II. A Physical Investigation of the Donaldson Technique. G. J. Neary. Brit. J. Radiol. **16:** 263–269, September 1943.

The Donaldson technic in radium treatment of carcinoma of the cervix uteri is based on the Stockholm method and consists normally of three radium applications of 24 hours each, the first interval being one week and the second two weeks. Two slightly different sets of applicators are used, but in both vaginal applicators the filtration is 0.5 mm. of platinum plus 2 mm. of silver, which is equivalent to 1 mm. of platinum. The uterine tube is about 6 cm. over-all length and 6 mm. in diameter and is slightly bent at the middle to correspond to a moderate anteflexion of the uterus of 15°. In the first type of tube, the National Radium Commission 50 mg. intra-uterine applicator, the filtration is 3 mm. of silver only, which is equivalent to about 0.8 mm. of platinum; there is a single cavity of 4.6 cm. total length. In the second type, the 60 mg. Donaldson tube, there are two separate capsules, 0.5 platinum screen, in an envelope of 2 mm. of silver; the active lengths of the two capsules are each 2 cm. and the distance between them is 8 mm.; the cervical half of the applicator contains 15 mg. and the other half 45 mg. The vaginal applicator is the Donaldson butterfly pessary, consisting of two adjustable boxes on two arms attached to a central stem. The butterfly pessary of the first type has in each box five tubes of 6.25 mg. content, making a total of 62.5 mg. in the vagina; the second type has somewhat smaller boxes and each box contains five tubes of 5 mg. content, making a total of 50 mg. in the vagina. During treatment the boxes lie in the lateral fornices and the distance between them depends on the individual case.

The dose delivered by the Donaldson technic was evaluated in air disregarding tissue absorption. No material change was observed in various positions of the boxes in the fornices. The parametrium receives about 6,750 r. The principal lymph node near the lateral wall of the pelvis receives 1,900 r. Rectal dosages were measured directly with a condenser chamber in the rectum. The anterior wall of the rectum receives 3,000 r. Because of the changes in position it was not practical to determine bladder doses.

There is no evidence that the vaginal vaults receive higher doses with the boxes than with corks, etc. Very little of the mucosa receives more than 14,000 r. The boxes may be regarded as point sources for distances greater than 2 cm.

SYDNEY J. HAWLEY, M.D.

Lymphosarcoma of the Gastro-Intestinal Tract. Report of Twenty Cases. Barton McSwain and John M. Beal. Ann. Surg. **119:** 108–123, January 1944.

Twenty cases of lymphosarcoma of the gastrointestinal tract, microscopically confirmed, are added to the considerable number previously reported. The largest number of cases occurred in the stomach and large intestine—7 each. The duodenum was the only part of the alimentary tract not represented in the series.

The symptoms are similar to those produced by other lesions of similar location. The most significant finding is a mass appearing soon after the onset of symptoms or a large mass in a patient in good general condition. Because of the similarity of the findings to those of carcinoma, roentgenologic diagnosis is seldom made. The points to be remembered in lymphosarcoma are the large size of the lesion in relation to the duration of symptoms and the presence of whorl-like defects in the barium outline of the stomach. In the colon a double or unusually long mass suggests lymphosarcoma. The gross appearance at operation is suggestive of the diagnosis; the histologic findings are conclusive.

Treatment consists in complete removal of the lesion if possible, with postoperative roentgen therapy if the operator is not certain that the lesion has been entirely eradicated. In the present series cures of five or more years were obtained after roentgen therapy alone in one case, after surgical extirpation in one, and after a combination of the two in one. Nine patients (47 per cent of those followed) were alive and well at the time of the report, without evidence of recurrence from one year to nine and a half years after the diagnosis was established. The mortality for the series was 42 per cent. The average duration of life for the 8 patients who died was 24 months. The average for the entire series was 37 months, but in several instances the diagnosis was only recently made. One patient was alive after seven years and one after nine years. Where metastasis has occurred, the outlook is poor. G. A. CREEL, M.D.

Recurrence of a Teratoma Testis Eleven and a Half Years After Orchidectomy and Irradiation. Percy Zerman. M.J. Australia **2:** 315–316, Oct. 16, 1943.

This case is reported because of the unusually long interval between operation and recurrence. Metastases were not observed until eleven and one-half years after removal of the primary testicular tumor.

The patient, twenty-four years of age, noticed a swelling of the right testicle. Shortly afterward the testicle was injured in an automobile accident and the swelling increased. Examination showed the enlarged testicle to be the size of a hen's egg; it was smooth, round, and not tender. The left testicle was normal. No masses were felt in the abdomen. A diagnosis of neoplasm was made and a simple orchidectomy was done. Two weeks later a 99-mg. radium pack was applied, centered over the umbilicus, for a dose of 8,500 r at the skin surface. Pathological examination of the operative specimen showed a teratoma, "possibly malignant," but no involvement of the cord or epididymis.

On examination eight years after operation no abdominal or inguinal nodes were palpable. Three years later, however, the patient entered the hospital with several small, stony-hard nodes in the right groin. These proved on section to have a teratomatous structure. Nine radon needles were implanted in a single plane, for an estimated dose of 8,000 r at a point 1.0 cm. below the center of Poupart's ligament. Two months later the nodes had decreased in size, but the patient now had a persistent productive cough. In another month the cough was worse and he was expectorating copious amounts of whitish sputum. A chest film showed nodular fibrosis of the lungs which was thought to be due to an unusual type of metastasis. Death occurred seven weeks later.

Postmortem examination showed a normal left testicle. Metastatic tumor deposits studded the lungs and were confluent at the bases, which were practically solid with tumor tissue. Several lumbar and many para-aortic nodes were involved by new growth. The principal elements of the metastases resembled an adenocarcinoma of the alimentary tract.

Although teratoma is usually considered to be radioresistant, the inguinal deposits in this case decreased markedly in size following radon therapy and were impalpable shortly before the patient's death. It is probable that the postoperative irradiation may have been sufficient to inactivate the early lymph node metastases and that fibrosis of the regional lymphatics served to delay further spread for many years.

DONALD R. LAING, M.D.

NON-NEOPLASTIC DISEASE

Course of Postoperative Parotitis under Radiation Therapy. Franz Buschke and Simeon T. Cantril. West J. Surg. **52:** 21–28, January 1944.

Radiation therapy by means of radium or x-rays is followed by regression of postoperative parotitis without suppuration in 65 to 70 per cent of cases and by eventual recovery in spite of suppuration in 15 to 20 per cent. The percentage of deaths in the reported series is fairly constant, being between 10 and 20 per cent.

The usual course is distinct clinical improvement twenty-four to forty-eight hours following irradiation, with sudden cessation of the severe general intoxication, despite increased swelling and edema of the gland during this period. Complete disappearance of the parotitis occurs in eight to fourteen days.

Why a certain number of cases go on to suppuration in spite of treatment is the problem with which the authors are chiefly concerned in this paper, but they are able to come to no definite conclusion on this point. Inadequate drainage, with development of severe edema of Stenson's duct is probably a factor. Suppuration occurs when the disease process breaks through the duct system and invades the glandular tissue. In successful cases, *i.e.*, those in which recovery ensues without suppuration, it would appear that the irradiation has controlled the infection before destruction of the walls of the larger salivary ducts, though no histologic proof of this assumption is available. The nature of the offending organism seems to have no relation to the outcome. The 4 cases in the authors' series that went on to suppuration were treated by sulfonamides along with x-ray therapy, while only one of the 12 patients with an uneventful recovery received chemotherapy. An opinion is expressed that in many of the cases that end fatally, the original condition rather than the parotitis is the cause of death.

LESTER M. J. FREEDMAN, M.D.

Roentgen Irradiation in Polycythemia Vera by Multiple Small Doses to Large Areas of the Body. Laurence L. Robbins. Am. J. Roentgenol. **51:** 230–235, February 1944.

An analysis is given of 20 cases of polycythemia vera treated at the Massachusetts General Hospital during the past ten years with small doses of roentgen radiation to large areas of the body. The daily dose consisted of 20 to 50 r and the total doses varied from 200 to 1,200 r per series, the majority of patients receiving 500 to 600 r per series. The field covers the body from knees to neck. This is accomplished by using a 20 × 20 cm. cone and a target-skin distance of 215 cm. The other factors were 200 kv., 0.5 mm. Cu plus 1 mm. Al filter, giving a half-value layer of 0.92 mm. Cu. Weekly white blood counts were done until a normal range was reached; then they were checked daily. A fall in the white blood cells below 4,000 or 5,000 warrants an interruption of treatment.

An analysis of the results obtained in these cases emphasizes two important advantages for this method of treatment. First, it caused no definite ill effects; second, it resulted in longer remissions than had followed other forms of therapy. The method is no more dangerous than others and does not cause roentgen sickness as a rule.

L. W. PAUL, M.D.

DOSAGE

A Simplified Method of Studying Volume Dose Distribution. E. M. Ungar. Brit. J. Radiol. **16:** 274–278, September 1943.

In irradiating deep lying tumors, the delivery of an adequate dose to the entire mass is a serious problem and each case requires detailed study. The present discussion is confined to circular fields with axially symmetrical dose distributions. The method is a combination of the tinted chart of Holfelder and conventional depth dose charts and Mayneord's contour projector. The depth dose charts are made by cutting out tongues of blue tinted film base and laying them over one another. This gives a shaded chart in steps. These are used to determine the dose distribution not only in the plane of the central ray but in at least two planes above (or below) this and along the sagittal and coronal planes. This will produce a picture in three dimensions of the depth dose distribution.

SYDNEY J. HAWLEY, M.D.

Metabolic Effects of Therapeutic Doses of X and Gamma Radiations. J. S. Mitchell. Brit. J. Radiol. **16:** 339–343, November 1943.

Experimentally it is shown that therapeutic doses of x and gamma radiation produce significant changes in carbohydrate and nucleic acid metabolism, apparently by means of enzyme inactivation. The dependence of the change in nucleic acid metabolism (as measured by the cytoplasmic absorption of ultraviolet radiation) upon dose and dosage rate is studied in detail. Changes have been detected after 40 r (gamma). The change is practically constant for dosages from 250 to 4,400 r gamma rays and 280 to 1,000 r x-rays. An approximately constant increase in absorption was observed at dosage rates from 1 to 450 r per minute but low values were obtained for dosages under 0.9 r per minute (gamma).

In radiosensitive cases complete recovery occurred in twenty-four hours except in two cases of carcinoma of the vulva where the change persisted for at least thirty days.

SYDNEY J. HAWLEY, M.D.